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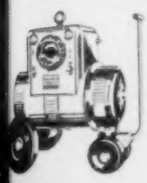

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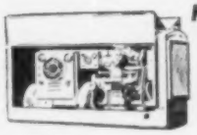

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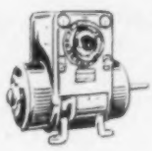

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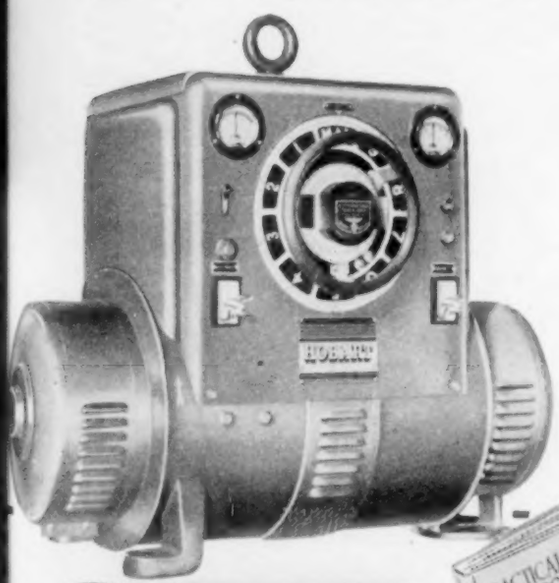

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All-Welded Composite Steel Beam and Concrete Slab Bridges*

By Glenn L. Enke†

Introduction

MODERN bridge design demands strict adherence on the part of the designer to the economical use of materials. This basic principle has assumed greater importance in recent years with sharply increased labor costs and ever-increasing demands for highway facilities.

Economical use of material may be interpreted as "complete" or "entire" use. This is accomplished by arranging all elements of a structure into an integral stress resisting unit. Current examples of successful design in this respect include an airplane wing, a "streamliner" railroad car, and a glued plywood box girder. Each of these use their exterior walls or "shells" as major stress resisting elements. Economical use of material also implies "least total cost" of labor and materials, and is achieved through simple construction details, repeated often. The all-welded composite steel beam and concrete slab bridge meets these requirements for economical use of materials.

Economical bridge design produces a least combined cost of bridge superstructure and substructure to satisfy given live load specifications; subject to under clearance requirements for waterway area, flood debris, navigation or, in the case of a grade separation structure, highway or railway traffic clearances. Bridge superstructure costs vary with span length to a considerably greater extent than do substructure costs, and for most bridge locations represent a major portion of the total cost. Since a short span will therefore produce an economical bridge, and span lengths in most bridges are dictated solely by economy, a span range of 20 to 100 feet will cover nearly all bridge construction.

Individually, short-span bridges attract little attention from engineers at large. On occasion, it is necessary to construct a bridge of major proportions across an important water way. Considerable attention is focused upon this type of structure because of its size; yet, in terms of financial expenditure per year, the small bridge of short-span length deserves real attention. Approximately 30 million dollars was spent in the United States by various state and municipal agencies in the two-year period covering 1940 and 1941, on bridges with spans of 40 to 80 ft. As very few individual bridge projects exceed this expenditure but require considerably more than two years to construct, the small bridge of short span deserves considerably more attention and thought than it now receives.

A 19% reduction in expenditure for bridges in the 40- to 80-ft. span range is worth approximately $2,800,000.00 annually. This paper will show that an all-welded composite steel beam and concrete slab bridge in the 60-ft. span range will save nearly 19% of the cost of the ordinary type of steel beam and concrete slab bridge, which does not utilize the concrete slab to resist stress.

It will also show that an all-riveted design can hardly justify the use of the slab in a composite girder section, as the high cost of providing a riveted shear key between slab and girder absorbs all but 3% of the saving.

It will show that the composite steel beam and concrete slab design is 10% more economical than an all-reinforced concrete design in the 60-ft. span range, whereas the ordinary riveted type of steel beam and concrete slab design costs 10% more than the reinforced concrete design in this span range. Prior to the use of composite steel and concrete slab designs, it was more economical to use reinforced concrete up to spans of 60 to 80 ft.; the variation in this length being determined by the relative prices for structural steel, reinforcing steel, and concrete in any one locality. Use of all-welded composite steel beam and concrete slab bridges will reduce this minimum economic span range to 40 ft. or less.

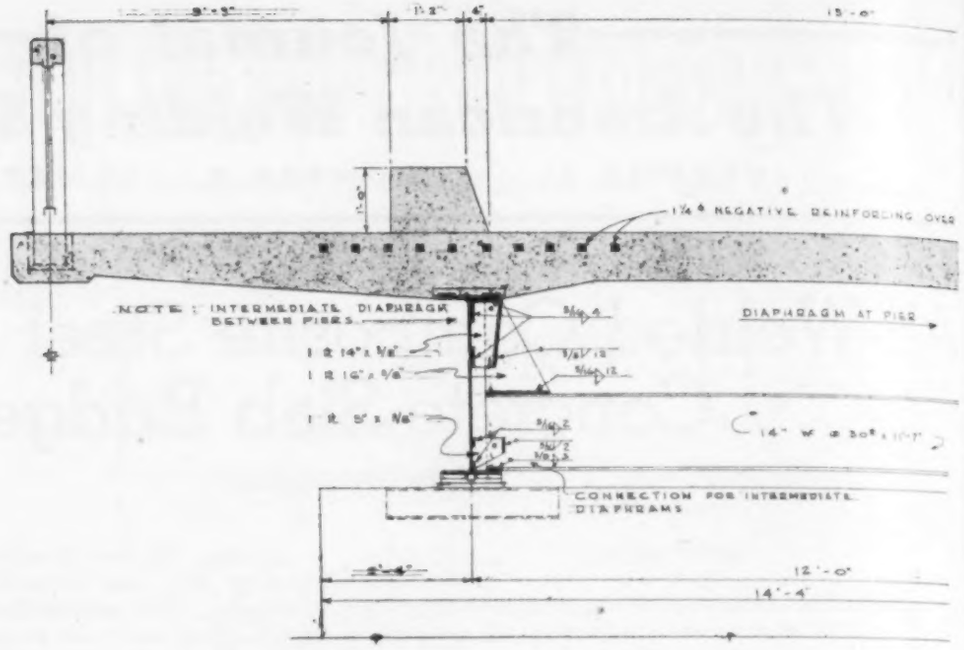
While this paper is primarily designed to show advantages of welding in structural steel bridge construction, there are other less tangible but important considerations that favor the use of structural steel in bridge construction over reinforced concrete.

Plastic flow of reinforced concrete subjected to high compressive stress produces an appreciable amount of deformation over a period of years. In shallow members subjected to dead load bending stresses, the continuous effect of this deformation results in noticeable deflections. A bridge constructed with reinforced concrete members spanning longitudinally (either flat slab or tee-beam design) will, in time, develop appreciable sags in each span between piers and produce a wavy deck surface with objectionable riding characteristics. This problem is not easily solved in concrete design because the total deformation is not limited, being, in general, proportional to time and unit stress and inversely proportional to bending stiffness. Short spans and deep members appear to provide the only practical cure, as the total amount of deformation accumulated is then within the limits of usual construction accuracy and apparent deck smoothness to the user.

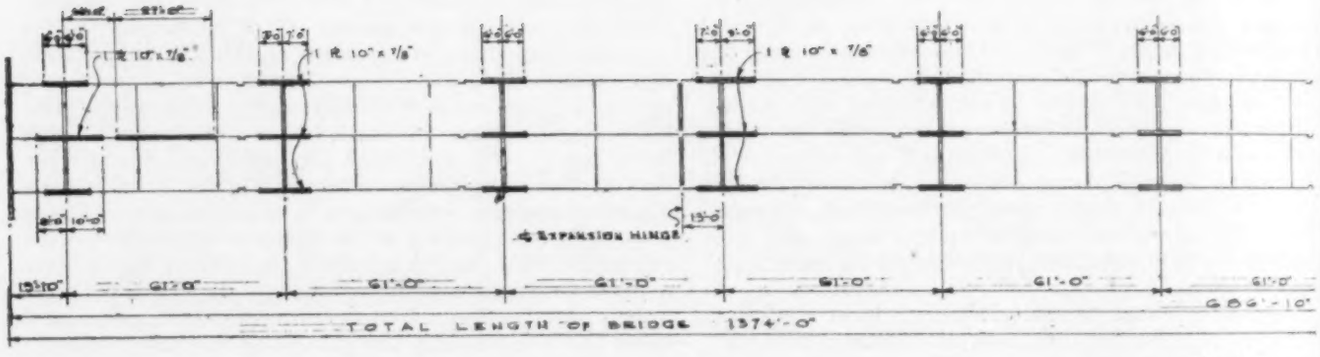
Shallow slab span designs in the 20- to 30-ft. span range have suffered from this phenomenon, beginning their useful life slightly crowned, and ending it with a center span sag too great for riding comfort and safety. The only reasonable cure at this stage is an asphalt topping

* Abstracted from one of the Prize Papers presented to the Lincoln Arc Welding Foundation.

† Design Engineer, Morrison-Knudsen Co., Inc., General Contractors, Boise, Idaho.

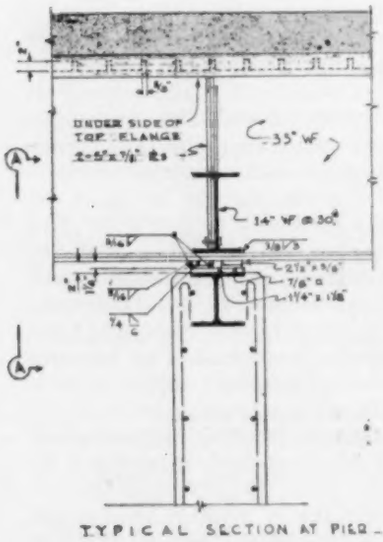


SECTION AT PIER

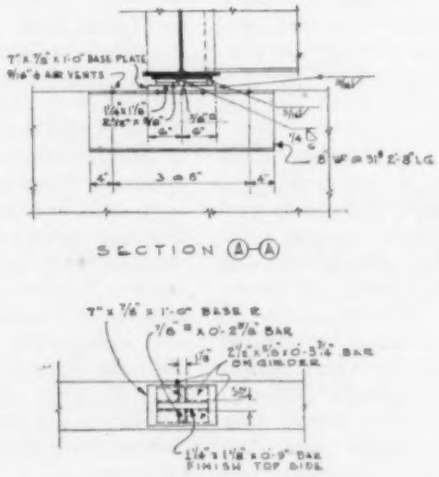


STEEL

Notes: All cover plates 10" x 5/8" unless noted

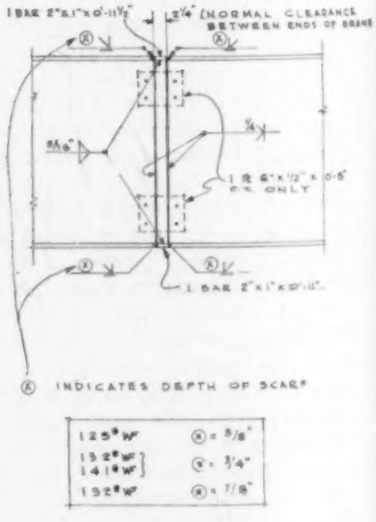


TYPICAL SECTION AT PIER


7" x 7/8" x 1'-0" BASE PLATE
9/16" ϕ AIR VENTS
8 WF @ 31# 2'-8" LG
3 @ 8"
SECTION (A)-(A)
7" x 7/8" x 1'-0" BASE PL
7/8" ϕ x 0'-2 9/16" BAR
2 1/2" x 5/8" x 0'-5 3/4" BAR ON GIRDER
1 1/4" x 1 1/8" x 0'-9" BAR FINISH TOP SIDE

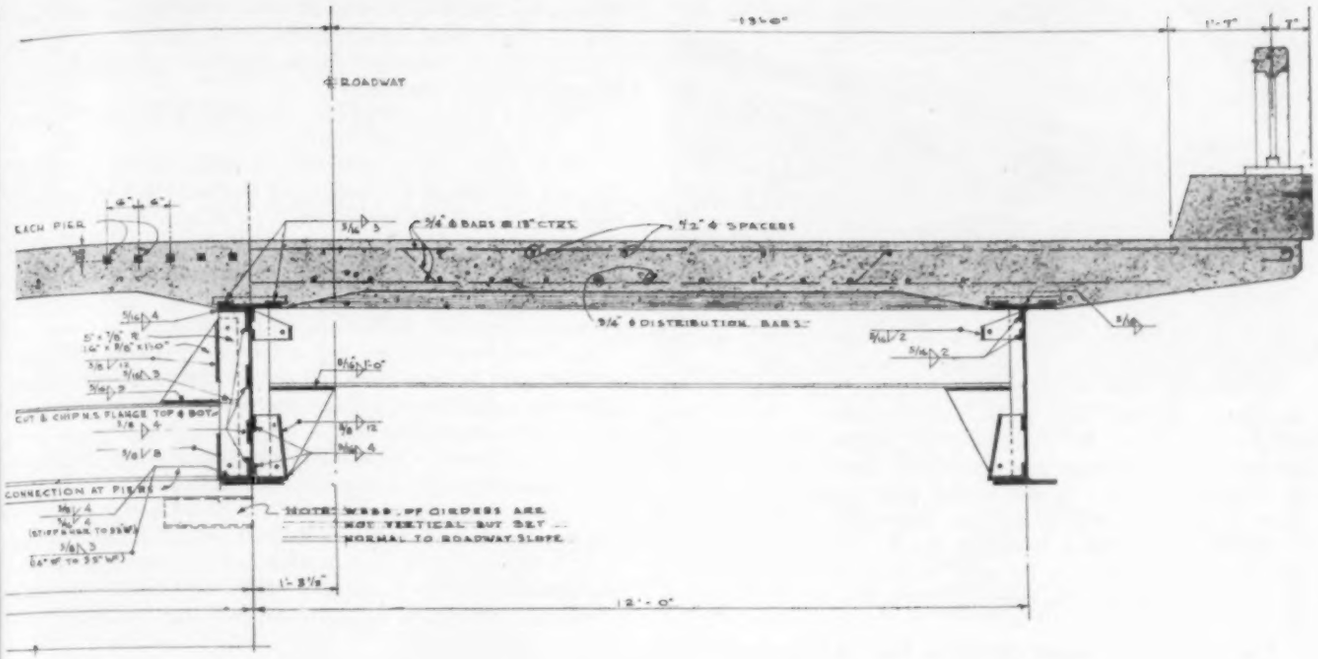
PLAN

BASE PLATE DETAILS

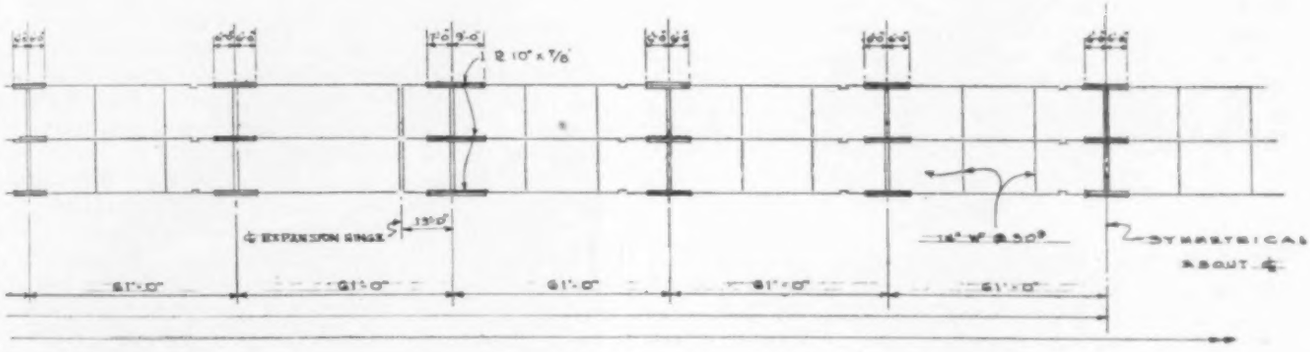

1 BAR 2" x 1" x 0'-11½"
2¼" (NORMAL CLEARANCE BETWEEN ENDS OF BEAMS
1 PL 6" x 1/2" x 0'-8" PL ONLY
1 BAR 2" x 1" x 0'-11"
(K) INDICATES DEPTH OF SCARF
125# WF (K) = 5/8"
132# WF, 141# WF (K) = 3/4"
152# WF (K) = 7/8"

TYPICAL SPLICE

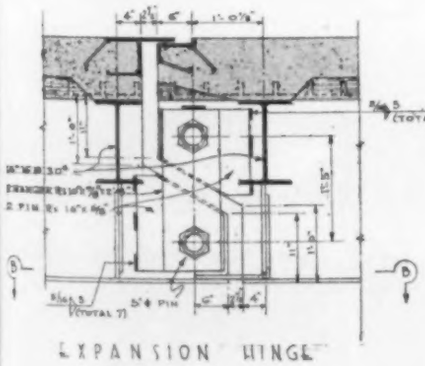
Fig. 1—Typical Sec


ROADWAY
EACH PIER
CUT & CHIP N.S. FLANGE TOP & BOT.
CONNECTION AT PIERS
NOTE: WEBS OF GIRDERS ARE NOT VERTICAL BUT SET NORMAL TO ROADWAY SLOPE
12'-0"

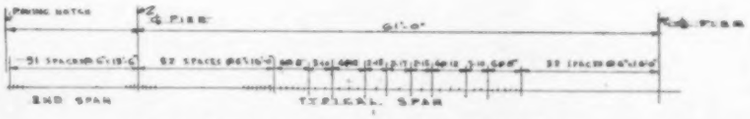
SECTION AT EXPANSION JOINT



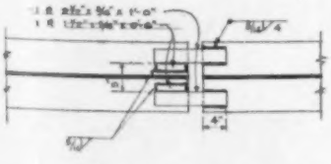
LAYOUT



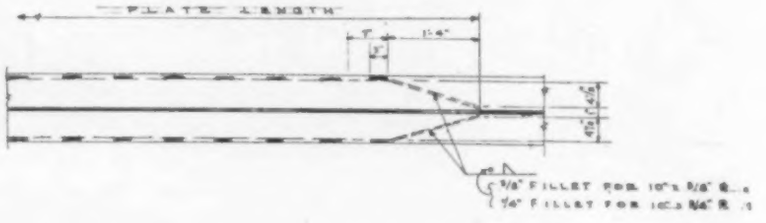
EXPANSION HINGE



SHEAR KEY SPACING FOR ALL GIRDERS



PLAN SECTION Ⓑ—Ⓑ



TYPICAL COVER PLATE

tions Welded Bridge

Fig. 2—Oildale Bridge—Side View

which increases dead load, and decreases usable live load capacity.

Structural steel bridges with longitudinal girders supporting concrete deck slabs with transverse reinforcing overcome all of the ill effects of plastic flow. As the modulus of elasticity for structural steel, at 29,000,000 to 30,000,000 psi., is controlled much more accurately than concrete, which ranges between 3,000,000 and 6,000,000 psi., deck deflections in a longitudinal direction are accurately allowed for and maintained, as structural steel is not subject to time deformation, that is, plastic flow.

The transverse span concrete deck undergoes plastic flow, of course, but in a direction *normal* to traffic, producing *uniform* deformations along any one wheel line or traffic lane throughout the entire length of bridge. To successfully achieve this effect, cross diaphragms must not be in contact with the concrete deck because uniform deflections and good riding occur only with uniform stiffness of deck in the transverse direction. As smooth riding and good alignment are the only factors of interest to the average highway user, this feature of all-welded steel composite bridges deserves major consideration.

History

Two all-welded highway bridges, Kern River Bridge at Oildale, near Bakersfield, Calif., and San Juan Creek Bridge near Paso Robles, Calif., featuring use of the concrete roadway slab as an integral part of the steel girder section, were designed by the writer while with the California Bridge Dept. and constructed by California Division of Highways in 1941. These bridges, referred to hereinafter as Oildale Bridge and San Juan Creek Bridge, were designed and constructed to conform to AMERICAN WELDING SOCIETY Specifications, which, however, were not at that time and are not now recognized by the American Association of State Highway officials for main stress carrying members.

The A.A.S.H.O. viewpoint on welding is stated in their 1941 Specifications as follows:

"Welding is not permissible in main members or their connections where the failure of the weld would endanger the stability of the structure."

Briefly, this viewpoint says: "Welding is not reliable." The writer firmly believes the reverse to be true, assuming intelligent designing for welding, and carefully planned shop and field welding procedures.

As these two bridges did not lie on Federal Aid Highway routes, it was possible to construct them without adherence to the welding restrictions set forth in the A.A.S.H.O. Specifications.

By coincidence, Oildale Bridge was adjacent to, but on a different highway route than another bridge in Bakersfield, two miles away, across the same Kern River, referred to hereinafter as Bakersfield Bridge. Both bridges were advertised for bids within a three months' period. Bakersfield Bridge is on a Federal Aid Highway route, however, and could not employ welding for main members.

The concrete slab on Bakersfield Bridge was not allowed by U. S. Bureau of Public Roads for composite action to resist dead load, as welded shear keys were used. The Bureau did, however, permit its consideration for live load only in view of the relative improbability of maximum live loads ever being on the structure.

It is therefore possible to show comparative costs of the all-welded design with full composite action of concrete slab versus a similar riveted design with a limited amount of welding on secondary members, and relatively little use of the slab in composite action.

Typical details of Oildale Bridge are reproduced herein, together with detailed estimates of welding cost, and probable riveting cost if riveting had been used. Oildale Bridge did not conform in all respects to the plans, however, in constructing the girder field splices. The contractor elected to mill the 61-ft.-span rolled girder beams to exact length, to obtain an $^1/_8$-in. fieldwelding clearance, rather than using the filler bar arrangement shown on the plans. Difficulties arose due to joints not matching up to give a uniform $^1/_8$-in. clearance. Further difficulties appeared during erection, as fabricated lengths did not exactly match pier locations. It was agreed on the job

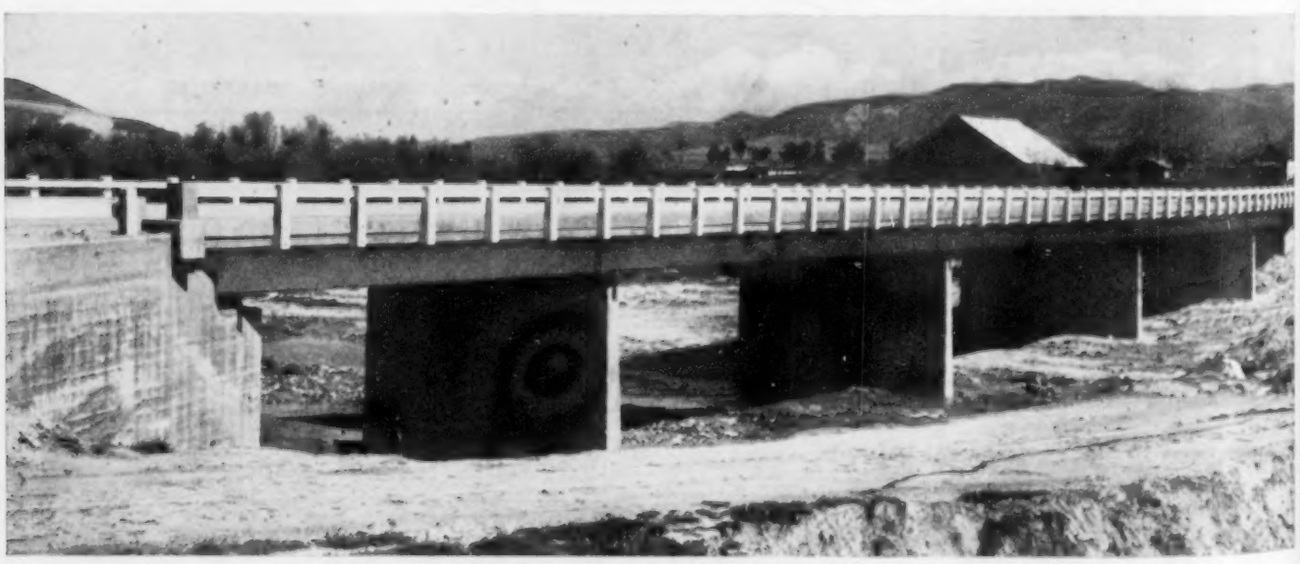


Fig. 3—San Juan Creek Bridge—Side View

that the filler bar arrangement as called for on the plans, which provided for field adjustment was preferable to the one used.

San Juan Creek Bridge construction conformed to the plans, but was rather poorly fabricated. One noticeably bad shop error occurred in scarfing the bottom flanges of the rolled girder beams from under side, instead of top side, which required all overhead welding on the bottom flange splices instead of downhand flat welding as had been planned.

Details of Design

1. *Composite Girders*

Welding offers large economies in the design of composite steel beam and concrete slab bridges, in which the concrete slab is used as the top flange of a "tee" girder section.

Fig. 4—Oildale Bridge—Underside Details

Note clean appearance of girder and absence of brackets to support slab.

Rolled steel beam and riveted steel plate girder spans represent one of the earliest modern types of bridges. Scientific development of design and construction of reinforced concrete to its present high standard of quality has led to the use of a concrete deck slab supported upon longitudinal steel beams or girders. This highway bridge type is the most successful one ever developed, for reasons noted earlier in this paper, as "time" deflection of the concrete slab due to plastic flow produces transverse deformation only and does not affect the surface riding qualities of the bridge.

Very few bridges of this type, however, have used the concrete slab as a top flange. This has been due, among other reasons, to the difficulty in providing a good riveted shear key to resist horizontal shearing stresses between the top girder flange and the concrete slab. To ignore this stress is to assume that each girder will deflect under load without restraint, the top girder flange will shorten, and the roadway slab, not being subjected to stress and therefore unchanged in length, will slip along the top

Fig. 5—Oildale Bridge—Steel Superstructure

Note absence of transverse slab support, insuring uniformly smooth concrete riding surface.

flange of the steel beam. Actual results show an undetermined amount of friction. Because it is undetermined, two bad effects result:

1. The ability of the slab to resist stress is neglected, resulting in the use of an excessive amount of steel in the girder.

2. Dead load deflections cannot be accurately determined. This frequently results in undesirable riding qualities of the finished bridge deck, when an estimated (rather, an assumed) deflection fails to materialize, or is excessive. A positive shear connection permits an accurate determination of deflection of the composite section, subject only to the usual variation in modulus of elasticity of the concrete.

Welding is ideal to overcome this condition as it permits practically any type of shear key to be economically connected to the flange using fillet welds of proper length and size to develop the horizontal shearing stresses.

2. *Shear Keys*

A riveted shear key on a rolled beam requires the drilling of holes in an otherwise blank top flange. (All of the deeper wide flange beam sections have a flange too thick to punch.)

An angle shear key is probably the only satisfactory type using rivets, but it requires a horizontal leg of sufficient length to accommodate a line of rivets. The vertical angle leg, however, is the only useful part of the key as the vertical area in contact with the concrete times the permissible unit bearing stress against concrete in a

Fig. 6—Oildale Bridge—Progress View

Note falsework bents to eliminate dead load stress from the girders until concrete deck is poured.

confined area determines the shear value of the key. As this vertical leg is subjected to heavy bending stress a fairly thick leg is necessary to permit any reasonable height of angle. As the horizontal leg must be equally thick and of sufficient width to accommodate rivets, 50% or more of the angle weight is wasted in engaging rivets rather than in resisting shear.

Zee shapes have been used for this purpose but are difficult to obtain due to infrequent rolling schedules and require even more metal. They do serve to lock the slab down to the beam, which, however, is an advantage more apparent than real, because bending stresses in a beam do not cause vertical separation of beam elements.

A welded shear key comparable to a riveted angle is a single bar of proportionate height and thickness *welded* to the flange. No metal is wasted; all of the key is used to resist shear. A welded key therefore weighs 50% or less than a riveted key of equal shear value.

From a practical standpoint further economies appear. Rivets in an angle must be arranged symmetrically in pairs using not less than two rivets to secure equal loading. This means that the shear key value changes by increments of 12,000 lb. or 16,000 lb. ($^{3}/_{4}$-in. or $^{7}/_{8}$-in. rivets). Welded shear keys may be proportioned to any shear key value, using a size and length of fillet weld to meet exact requirements.

Considerable waste is therefore present in the riveted arrangement, as it is unusual when equal strengths will result in both rivets and angles; further, angle widths in the desired range vary by $^{1}/_{2}$-in. units, whereas flat bars for welding may be obtained from stock in $^{1}/_{4}$-in. increments. Extreme flexibility in design is therefore obtainable with the welded key in addition to the initial weight saving of 50% or more.

3. Girder Splices

A butt-welded field girder splice is used with the following essential characteristics:

(*a*) A nominal 2-in. field clearance between ends of girders is provided for erection purposes.

(*b*) Ends of beams are square cut (either hot sheared at the mill or flame cut in the fabricating shop).

(*c*) Flanges and webs are flame scarfed for welding. Flanges are scarfed from the top only with single vee to permit downhand welding. Webs are scarfed from both sides for a double-vee weld.

(*d*) Filler bars of proper width are selected in the field after girder erection inserted into the opening, and field welded to each end of each girder.

Allowable stresses on this type of joint are 85% of the full section in conformance with AMERICAN WELDING SOCIETY Specifications because of the single-vee flange weld. This is ample, however, as the splice is always located near the 0.25 point in the span where maximum positive or negative moments for dead plus live load rarely exceed 40% of the beam strength. The advantage of downhand welding is considerable, as overhead welding from staging hung on the beam is difficult and expensive. A final overhead pass is necessary on the flanges after cleaning out the root of the first downhand pass.

The nominal 2-in. field clearance requires filler bars $1^{3}/_{4}$-in. wide, and of thicknesses equal to beam flange and web thicknesses for proper butt welding of the splice. As the nominal 2-in. clearance may vary considerably, due to mill cutting tolerances if hot sheared, and temperature at time of erection, stock lengths of bars in widths varying by $^{1}/_{4}$ in. are made available to the job, thus insuring a field welding clearance on each side of the filler bars of not greater than $^{1}/_{8}$ in. These bars are readily flame cut to length in the field. In the event a tapered filler bar becomes necessary due to vertical curve, camber or inaccurate beam cutting, a suitable bar can be flame cut to proper shape at the job with trouble.

For greatest economy composite beam and girder spans should be supported at their third points with temporary bents until the slab has been poured, as it permits the composite section to resist full dead load as well as live load. It also furnishes false work for steel erection which, while not essential, is very desirable and affords opportunity to jack the beam into exact position at the splice and requires a bare minimum of splicing material for fitting up purposes.

In the two completed structures described herein, two small splice plates fastened on one side of the web, with two bolts in each plate were sufficient to rigidly hold the splice in position for field welding. These were removed as soon as tack welding of the filler bars was completed.

Specifications and drawings covering girder splice construction required the use of step welding, with total amount of weld kept symmetrical about both axes of the beam. The welding schedule for field splices provided for welding of all splices in any one span; from this span in both directions toward a deck expansion joint.

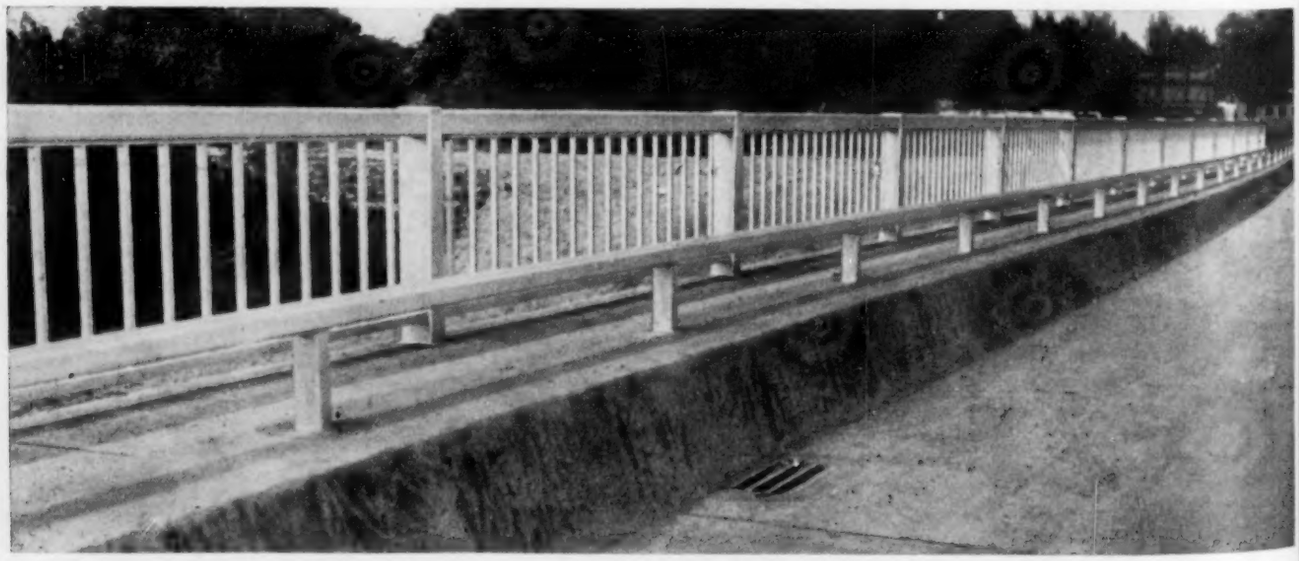


Fig. 7—Oildale Bridge—All-welded Tubular Handrail and Guardrail

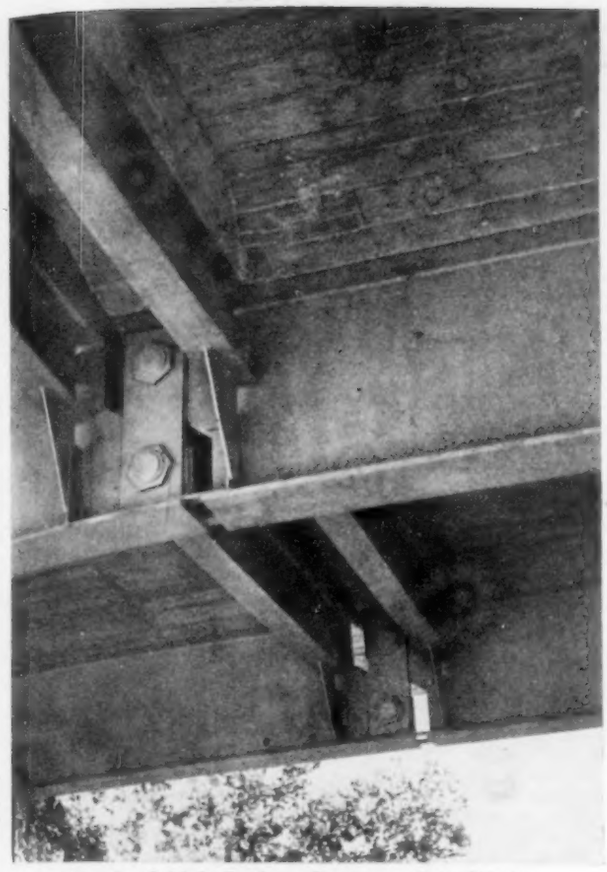


Fig. 8—Oildale Bridge—Expansion Joint Details

Temperature and shrinkage stresses in the splice during the welding process were largely eliminated by providing a temporary sliding connection on each pier. This procedure reduced shrinkage stresses due to welding to a minimum and assured an accurate control of temperature stresses in the finished structure. Girders were welded down to the piers, only after all splices were welded, concrete decks poured, and at an average air temperature for the region.

4. Pier Bearings

The pier bearing is a compact welded plate assembly using a $2^1/_2$-in. wide rocker bar resting upon a base plate. The edges of the rocker are chamfered to prevent excessive edge stresses when beam rotation occurs due to deflection.

This construction is much less costly than machining the rocker bar to a large radius, but serves the same purpose in a practical way, as the angular deflections at this joint due to live load and temperature are extremely small. Small keeper bars prevent lateral and longitudinal slippage and effectively transmit temperature and earthquake stresses to the pier, yet do not interfere with the hinging action of the joint for rotation.

The pier assembly for each girder is field welded to a small beam set flush into the top of the concrete pier. This beam contains less steel, is more rigid than a base plate, requires no anchor bolts, and is installed during concreting operations on the pier.

The absence of anchor bolts in the welded assembly is particularly helpful during construction, as a slight misalignment in any direction is of no consequence. The bearing beams must be held to proper grade, which, however, is not difficult, as the beams bolt through the top flange to cross struts directly to the pier forms.

A similar bearing assembly design in riveting would involve expensive countersinking of rivets and in general produce a weak joint. For this reason, other types of bearings, such as a steel pin between two steel castings, have been more satisfactory than a riveted bearing. The total cost of this welded bearing plate assembly is approximately 20% of a cast-steel assembly and is distinctly more compact and better appearing.

5. Cross Diaphragms

Intermediate cross diaphragms between longitudinal girders in a bridge serve two purposes:

1. Distribution of live loads between girders when live load is applied eccentrically to the bridge in the central portion of the span. This eccentricity results in unequal girder deflections, and creates severe shearing and bending stresses in the intermediate diaphragms.
2. Provides rigid edge support to the roadway slab at slab expansion joints. A rigid diaphragm is very important at these locations, as the passage of live load across an open slab joint causes high impact and a rough riding surface unless both edges of the slab are at the same elevation and rigidly supported.

The all-welded diaphragm used in this design is shop fabricated from a 14-in. WF at 30 lb. and two gusset plates, one at each end, butt welded against the beam flange, parallel to and in line with the beam web.

The intermediate diaphragms are erected with the 14-in. beam supported upon the bottom flange of the girders with gusset plates lap welded against stiffener plates on the girder webs. Two erection bolts are used to hold the diaphragm in position for field welding. Weld positions are arranged to eliminate overhead welding. The roadway slab does not rest upon these diaphragms, as it is important that intermediate transverse slab supports be eliminated in the interests of a good riding surface, for reasons described earlier in this paper.

End diaphragms at expansion hinges are identical to the intermediate diaphragms, but lap under the girder top flanges, with gusset plates underneath. The roadway slab is supported upon these diaphragms as noted above.

The diaphragm design described herein, and shown in the accompanying illustrations has proven very satisfactory in the finished structures. The decks are noticeably more rigid than similar riveted structures under passage of live load in spite of the high ratio of length to span depth and show a marked reduction in vibration due to live load impact. While the rigidity is accom-

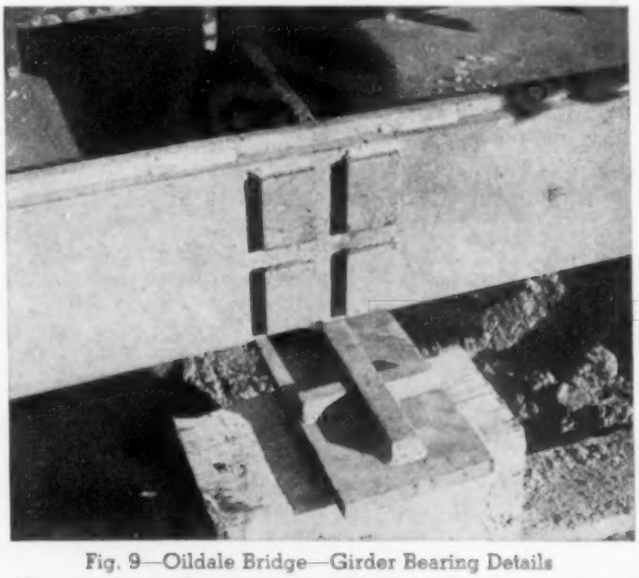


Fig. 9—Oildale Bridge—Girder Bearing Details

Note simplicity of construction. This bearing transmits lateral, longitudinal and vertical forces, while functioning as a longitudinal rocker.

plished principally by making full use of the slab with a good type of welded shear key, the all-welded diaphragms play their part in reducing the impact vibration that is noticeable to a marked degree in an all-riveted span.

6. Girder Expansion Joints

Girder expansion joints, necessary to relieve temperature stresses, are located near the quarter point of a span to avoid disrupting the continuous girder arrangement. Distances between joints are dependent upon the flexibility of the concrete piers supporting the girders, which, in the two structures described, were made as slender as practicable and attached with a hinged connection, described earlier in the paper, to each girder.

In one of the structures described, pier heights were sufficient to permit a distance between expansion joints of 390 ft. This distance creates a total change in length of 3 in. over a 100° temperature range, requiring a normal joint opening of $1^1/_2$ + 1-in. clearance, or $2^1/_2$ in.

Two tension hanger plates, suspended from a steel pin through the cantilever side of the expansion joint, support the span on the other side of the joint by a similar pin. These pins extend through the girder webs which were reinforced with pin plates for bearing against each pin.

The pin plates are welded to the girder webs prior to boring the pinholes. As welding produces a rigid connection, in contrast to the considerable slippage necessary to cause a riveted joint to act, welded pin plates are definitely more satisfactory than riveted for this purpose.

Lateral motion of the span beyond the expansion hinge, due to wind or seismic forces, is prevented by two small guide bars, welded on one side of the joint to girder flange, and bearing against guide bars on the other flange. This detail is readily put together and field welded after the girders are assembled and adjusted to line and grade.

General Data

Structure:

Name of bridge	Oildale	San Juan Creek	Bakersfield
Total length	1374 ft.	260 ft.	630 ft.
Total width	35 ft. 6 in.	30 ft. 4 in.	30 ft. 4 in.
Typical span length	61 ft.	58 ft.	59 ft. 6 in.
Roadway width	26 ft.	26 ft.	26 ft.
Sidewalks	1–5 ft.	None	None
Structural steel:			
(*a*) Total weight in pounds	665,850	125,650	323,000
(*b*) Unit price per pound, fabrication	$0.065	$0.07	$0.0625
(*c*) Unit price per pound, erection	$0.02	$0.02	$0.02
Concrete: (structure)			
(*a*) Total volume in cubic yards	2025	410	960
(*b*) Unit price per cubic yard, in place	$18.50	$22.00	$18.00
Total cost of bridge	$169,920	$33,945	$83,220
Unit cost per square foot	$3.54	$4.30	$4.35

Estimated Welding Costs for Oildale Bridge:

Shop Welding Costs:

Size, In.	Type	Speed in Ft. per Hr.	Electrode Cons. Lb. per Ft.	Unit Cost: Labor	Electrode	Power	Total	Total Lineal Feet	Total Cost
5/16	Flat fillet	27.5	0.285	0.04	0.03	0.005	0.075	7928	$ 595
5/8	Flat fillet	20	0.37	0.05	0.04	0.007	0.097	917	89
1/4	Flat fillet	10	0.70	0.10	0.08	0.014	0.194	304	59
1/4	Flat butt	17.5	0.36	0.06	0.04	0.007	0.107	144	15
								Total cost	$ 758
								Operation factor 100%	757
								Total	$1515
								Equipment, overhead, profit, insurance: 100%	1515
								Total shop cost	$3030

Field Welding Costs:

5/16	Flat fillet	27.5	0.285	0.05	0.04	0.021	0.111	80	$ 9
5/16	Vert. fillet	15.5	0.325	0.10	0.05	0.024	0.174	89	15
1/2	Vert. fillet	12	0.40	0.12	0.06	0.031	0.211	498	105
1/4	Vert. butt	9	0.58	0.17	0.08	0.042	0.292	297	87
5/8	Flat butt	7.5	1.45	0.20	0.20	0.10	0.50	111	56
3/4	Flat butt	6	1.9	0.25	0.27	0.13	0.65	54	34
7/8	Flat butt	4.8	2.15	0.31	0.30	0.17	0.78	8	6
								Total cost	$ 312
								Operation factor 100%	313
								Total	$ 625
								Equipment, overhead, profit, insurance: 100%	625
								Total field cost	$1250
								TOTAL WELDING COST	4380
								12% Contingencies	520
								TOTAL	$4800

Additional Weight of Metal for Oildale Bridge if Constructed as All-Riveted Structure:

Location	Number	Unit Weight	Total Weight, Lb.
Girder splices	54	320 lb. (average)	17,300
Shear keys	6700	9.64 lb. (net increase)	64,500
Pier diaphragms	64	216 lb. (net increase)	10,000
Intermediate diaphragms	96	230 lb. (net increase)	23,500
		Total Weight	115,300

Net Increase in Cost of Riveted Over Welded Bridge at Oildale Due to Additional Weight of Metal:

Additional material cost—115,300 lb. at $0.0825 (unit bid price)	$ 9,500
Deduct cost of welded pier—69 units × 47 lb. ea. at $0.085 (unit bid price)	−200
Additional cost of cast steel pier bearings—69 units × 149 lb. ea. at $0.20 (prevailing local unit price)	2,000
Net total increase in cost due to weight of metal	$11,300

Shop and Field Punching, Drilling and Riveting Costs for Oildale Bridge if Constructed as Riveted Bridge:

NOTE: Unit prices shown represent averages quoted by various fabricators, and include labor, materials and all overhead costs.

	Number	Unit Price	Total
Punched holes	70,000	$0.05	$ 3,500
Drilled holes	30,000	0.25	7,500
Shop rivets	32,000	0.20	6,400
Field rivets	9,250	0.80	7,400
			$24,800

NOTE: The drilling and shop riveting required for the shear keys alone represent more than 50% of this total.

Additional Cost of Furnishing, Fabricating and Erecting Oildale Bridge if Constructed as Riveted Bridge:

Assume cutting, shearing and handling costs identical for both methods of fabrication.	
Deduct shop and field welding cost	−$ 4,800
Add shop and field punching, drilling and riveting costs	24,800
Add cost of additional weight of metal	11,300
	$31,300

Conclusion

An appreciable amount of saving in cost with use of arc welding is available. Two types of savings may be demonstrated for the all-welded composite steel and concrete slab highway bridge over similar or competitive types:

(1) Difference in cost between all-welded and all-riveted construction, both types making full use of the concrete slab as an integral part of the section.

(2) Differences in cost between:
- (*a*) All-welded composite type of construction,
- (*b*) Usual riveted steel type of construction not utilizing the slab as an integral part of the section,

Fig. 10—Oildale Bridge—Girder Splice Fitted up Prior to Welding

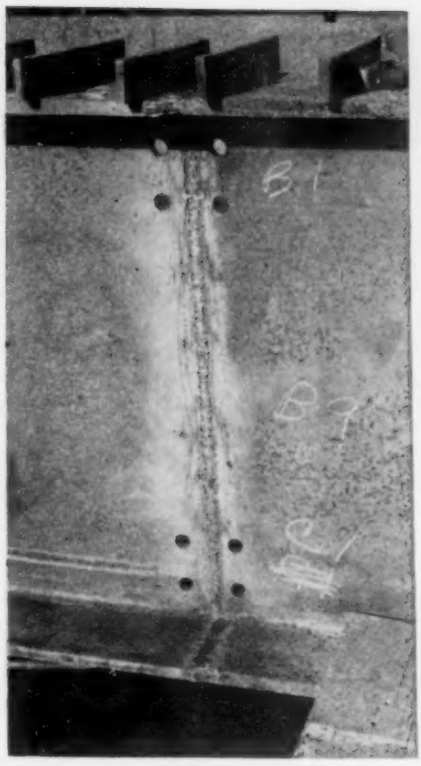


Fig. 11—Oildale Bridge—Girder Splice Completed. Erection Plate Holes Not Yet Plugged

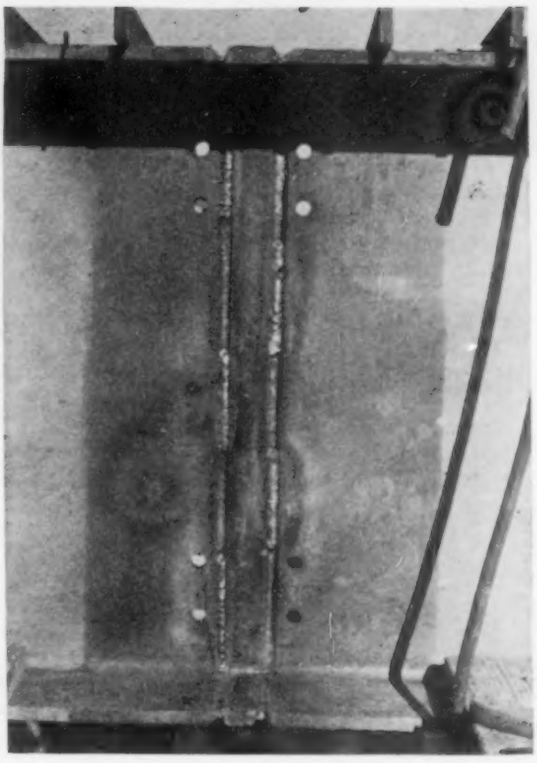


Fig. 12—San Juan Creek Bridge—Girder Splice Welding in Progress

Note stepped sequence of welding to reduce internal stresses.

(*c*) Usual reinforced concrete tee beam and slab type of construction.

Saving (1): Total cost of Oildale Bridge, an all-welded composite design, is: $169,920. Additional cost in materials, fabrication and erection if this structure were redesigned as an all-riveted composite design is $31,840. as noted under "General Data." Total cost of the Oildale Bridge as an all-riveted structure with full composite slab action would then be $201,800. Probable total cost of this same bridge constructed in the usual manner represented in the Bakersfield Bridge would be:

$$\$169{,}920 \times \frac{\$4.35 \text{ (unit cost of Bakersfield Bridge)}}{\$3.54 \text{ (unit cost of Oildale Bridge)}} = \$208{,}800$$

Saving in cost of the all-riveted bridge using composite slab action over one employing the usual type of construction is:

$208,800 − $201,800 = $7,000 or approximately 3%

Saving in cost of the all-welded bridge using composite slab action over one employing the usual type of construction is:

$208,800 − $169,900 = $38,900 or nearly 19%

The cost advantage of welding over riveting, including the benefits of composite slab action, is readily apparent.

Saving (2): Unit square foot cost of Oildale Bridge, an all-welded continuous composite steel and concrete design, is $3.54, as noted under "General Data." Unit square foot cost of Bakersfield Bridge, an ordinary riveted type of continuous steel beam and concrete slab design, not completely using the concrete deck slab to resist bending stresses, but similar in all other respects to Oildale Bridge, is $4.35. Unit square foot cost of a typical reinforced concrete tee beam bridge, of continuous type and similar in all respects to Oildale Bridge, is $3.94, determined from actual designs and costs prepared by the writer's bridge design class in 1940 and 1941, given in evening school at Sacramento, California, and attended by members of various organizations engaged in bridge and building construction.

Relative costs of Oildale Bridge and Bakersfield Bridge are: $\frac{\$3.54}{\$4.35} = 81.5\%$, or a saving of nearly 19% in favor of the all-welded composite design.

Relative costs of Oildale Bridge and a reinforced concrete bridge are: $\frac{\$3.54}{\$3.94} = 90\%$, or a saving of 10% in favor of the all-welded composite design.

Relative costs of Bakersfield Bridge and a reinforced concrete bridge are: $\frac{\$4.35}{\$3.94} = 110\%$, or a saving of approximately 10% in favor of the reinforced concrete design.

Approximately $2,000,000 was spent by the California Division of Highways in the two-year period 1940 and 1941 for construction of short-span bridges in the 40- to 80-ft. span range. Of this amount, approximately three-fourths, or $1,500,000, was spent on reinforced concrete bridges. The use of all-welded composite steel and concrete for all of the structures in the reinforced concrete group would have produced a saving of 10% of $1,500,000, or an annual saving of $75,000. This same type of construction substituted for the riveted steel design without composite action would have saved 19% of $500,000, or an annual saving of $48,000. A total annual saving to this Division of $133,000 is therefore possible.

Written inquiries sent to all of the State Highway organizations in the United States, and to selected municipalities that had an appreciable amount of bridge

construction, revealed the fact that approximately $30,000,000 was spent during the period 1940 and 1941 on bridges of all types in the 40- to 80-ft.-span range. Construction seemed fairly equally divided between reinforced concrete and structural steel bridge types, and for purposes of this analysis may be taken as 50% for each type.

A more favorable price relationship with concrete construction for structural steel exists throughout the country at large than exists in California, which accounts for the 3 to 1 ratio in favor of reinforced concrete in this state. Steel mill construction at Provo, Utah, and Fontana, Calif., should alter this situation and make all-welded steel construction even more competitive in the western states after the war.

Total annual savings possible, therefore, throughout the United States by the adoption of the all-welded composite steel beam and concrete slab bridge in the short-span range of 40 to 80 ft. would amount to 19% of $15,000,000 plus 10% of $15,000,000, or a total of $2,200,000.

Detailed descriptions appear in other portions of this paper describing the increased structural rigidity and better riding qualities of the bridge deck achieved through the use of all-welded composite steel beam and concrete construction. These advantages are not definable in terms of cost, yet contribute measurably to a more satisfactory bridge structure from the highway user's standpoint. Further, the service life of an all-welded bridge with composite slab construction is definitely greater than other structural steel types, due to the increased structural rigidity. Unfortunately, the two structures described herein have not been in operation for a long enough period of time to determine their maintenance costs. The writer feels, however, that they will fully justify his expectations for long and continuous service.

How to Make Cutting Machine Templets

By Rudolph Chelborg*

A HIGH degree of accuracy is easily obtained in parts shape-cut by the use of templets. However, the operator must understand the few simple principles of preparing the templets for use. Careful workmanship is important because any inaccuracy in the templet will be imparted through the cutting blowpipe to the shape being cut.

Templet Base Material

The base to which strip templets are fastened may be of steel, brass, or aluminum sheet, Masonite board, or plywood. Steel sheet is preferred as a base for those templet strip materials that can be attached by riveting. Standard templet rivets are tubular and are supplied in the proper length for use with $^1/_8$-in. thick base material and standard aluminum strip material, which is $^1/_4$ in. wide by $^7/_{16}$ in. high. With base material thinner than $^1/_8$ in., it will be necessary to file off some of the rivet so that it will not interfere with the cutting machine drive unit, while with material thicker than $^1/_8$ in. it will be necessary to countersink the rivet hole.

Base material less than $^1/_{16}$ in. thick is not recommended as it bends too easily during handling. On templets having base material $^1/_8$ in. or less in thickness, particularly large ones, the necessary stiffness may be

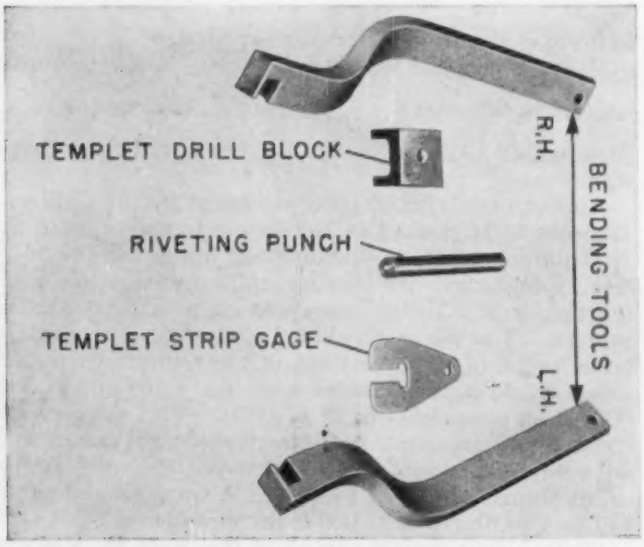


Fig. 1—These Are the Special Tools Required for Making Aluminum Strip Templets

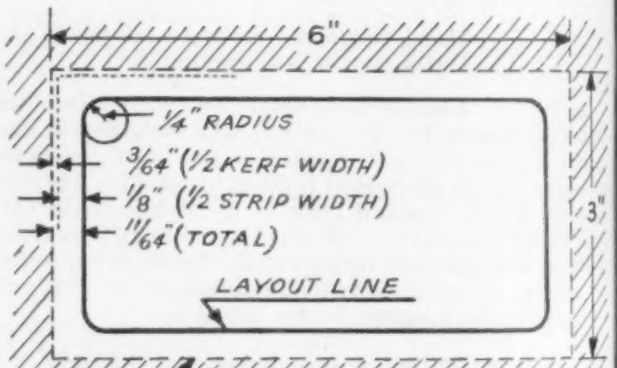


Fig. 2—In Laying Out the Templet for a HOLE the Layout Line Should Be Drawn Similar in Shape to the Actual Hole Desired, but Smaller at All Points by an Amount Equal to the SUM of One-Half the Templet Strip Width and One-Half the Kerf Width. Templet Strip Width Is $^1/_8$ In., and, in This Example, Kerf Width is $^3/_{32}$ In., Cut with a No. 6 Nozzle. Hence, the Layout Line is $^{11}/_{64}$ In. Smaller Than the Actual Size of Hole Desired

* Development Engineer, The Linde Air Products Co., Newark, N. J.

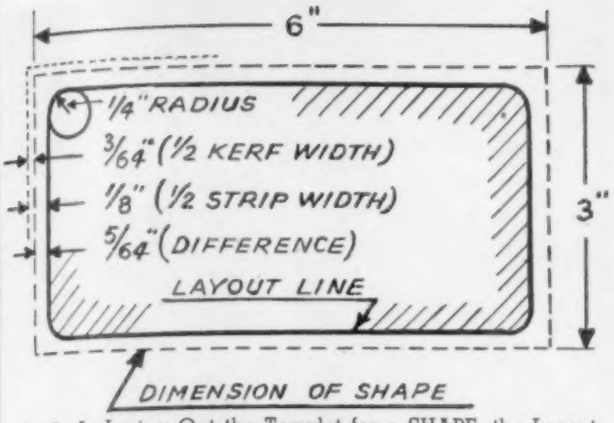


Fig. 3—In Laying Out the Templet for a SHAPE, the Layout Line Is Drawn Similar in Shape to the Actual Shape Desired, but Smaller at All Points by an Amount Equal to the DIFFERENCE Between One-Half the Templet Strip Width and One-Half the Kerf Width. As in Fig. 2, Templet Strip and Kerf Widths Are 1/4 In. and 3/32 In., Respectively. Hence the Layout Line Is 5/64 In. Smaller Than the Actual Size of the Shape Desired

provided by attaching light angle iron to the top surface. The thickness of the base material should not exceed 3/4 in., as it would then be necessary to raise the machine track to obtain proper clearance.

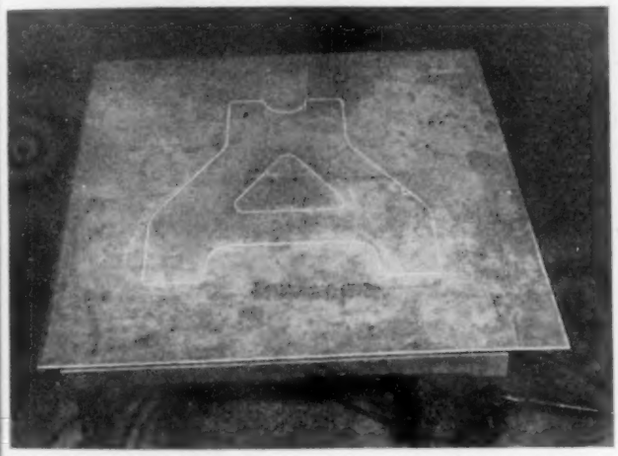


Fig. 4—For Ease in Forming the Templet, a Layout Line Is Located and Scribed Directly on the Base Plate

The following tools, in addition to those shown in Fig. 1, are required for laying out and making aluminum strip templets when 1/8-in. steel base plate and tubular rivets

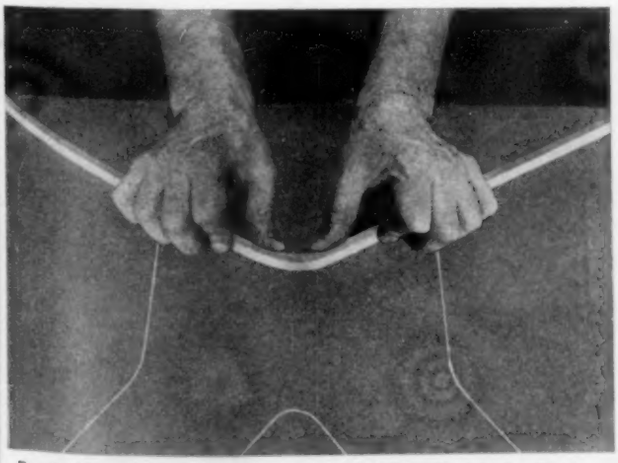


Fig. 5—Easy Curves Can Be Formed by Hand with the Bottom of the Templet Strip Resting Squarely on the Base Plate. The Entire Templet Should Be Formed in One Piece

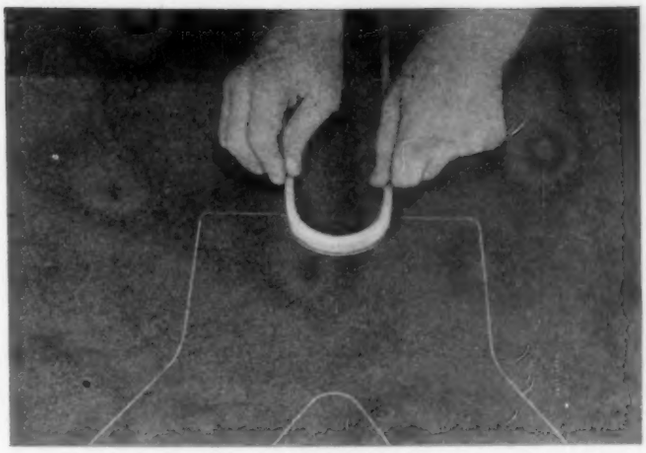


Fig. 6—The Inside Edge of the Strip Should Be Formed Against the Layout Line

are used: electric hand drill and No. 26 twist drill, metal scriber, pair of dividers, hammer, center punch, nail set, hacksaw, and a file for use on aluminum.

Kerosene or a mixture of white lead and machine oil should be used to lubricate the drill when making the holes for the rivets in the aluminum templet strip.

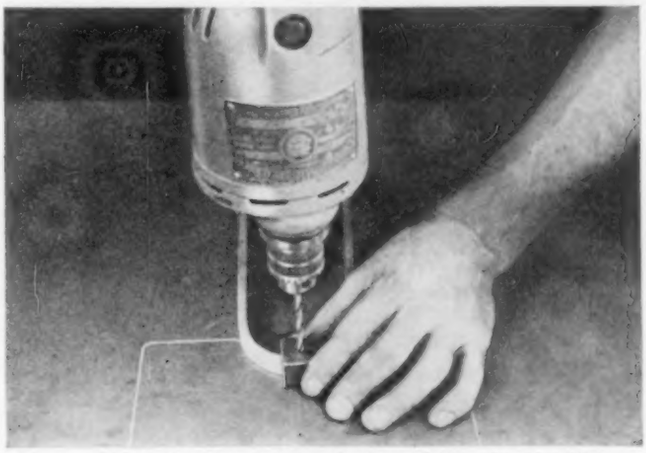


Fig. 7—A Pilot Drill Block Must Be Used When Drilling Holes Through the Templet so That the Hole Will Be in the Center of the Strip and Square with the Strip at the Base

Principles of Templet Layout

In templet-guided shape cutting, the center of the cutting nozzle follows a path that is an exact duplicate of the

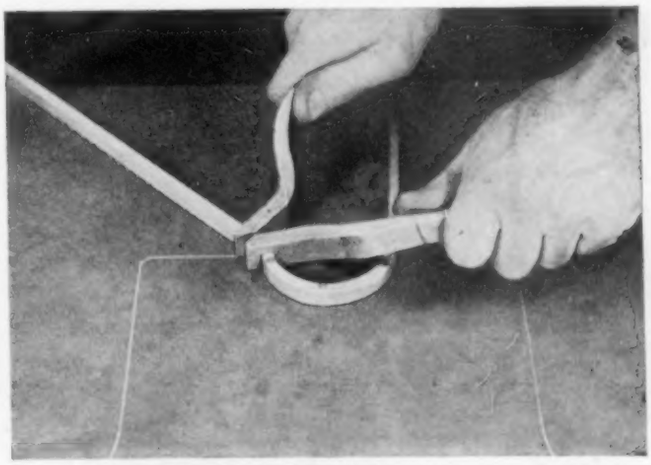


Fig. 8—Use Bending Tools to Form Sharp Curves. Insert Rivets Temporarily to Hold Formed Sections in Place

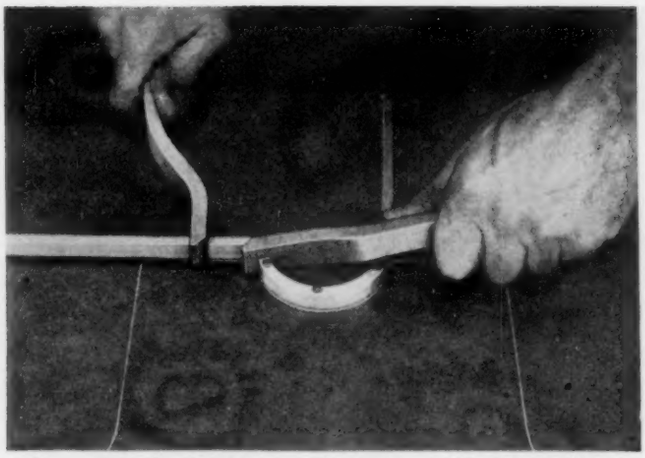


Fig. 9—The Flat Surfaces at the Bottom of the Tools Should Rest Squarely Against the Base Plate During the Bending Operation

center line of the templet strip. In laying out the templet, therefore, the strip center line must form a path that is *larger*, for shapes, or *smaller*, for holes, than the size of part desired by an amount sufficient to allow for the width of metal removed during cutting, or kerf width.

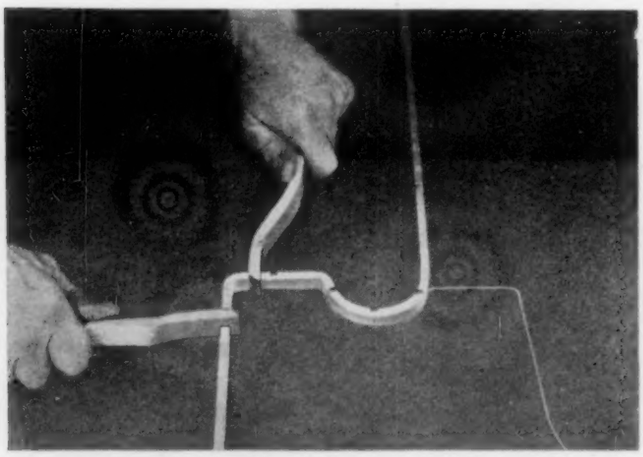


Fig. 10—The Bending Should Be Done with One Tool While the Other Is Held Firmly in Place

Allowance must also be made for any stock necessary for subsequent finishing.

For ease in forming the templet, a layout line is located, and scribed directly on the templet base plate, one-half the templet-strip width inside the desired templet-strip

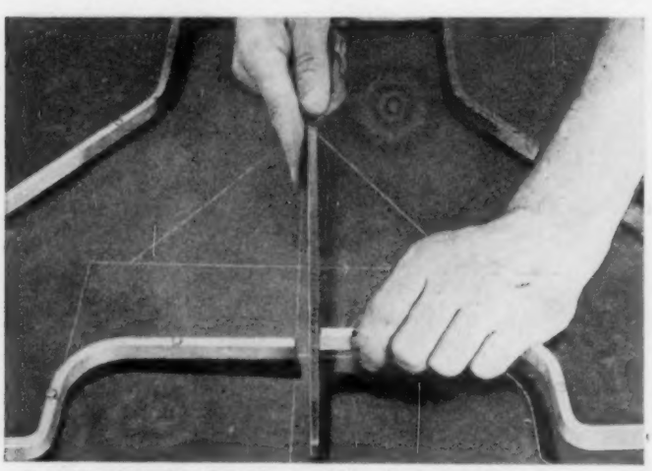


Fig. 11—File the Two Ends of the Templet Strip Square to Form a Tight Butt Joint

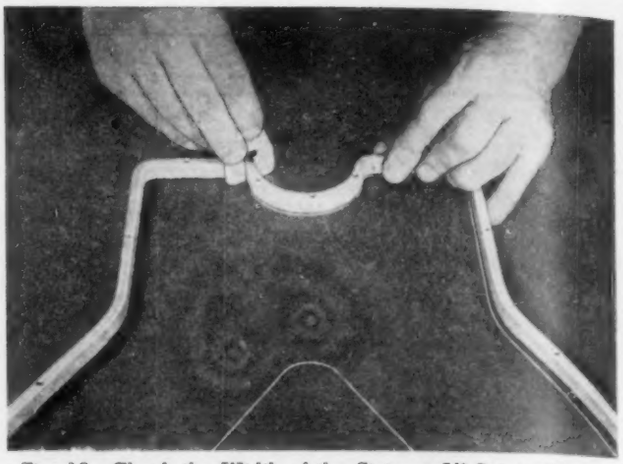


Fig. 12—Check the Width of the Strip at All Points, Using a Templet-Strip Gage

center line. The inside edge of the strip is then easily formed against this layout line so that the exact center of the templet strip will be directly over the templet-strip center line. Figures 2 and 3 illustrate these principles of templet layout.

Fig. 13—Lightly File Any Thickened Areas. Remove Only Enough Metal to Permit the Gage to Pass

Where exact dimensions are required in the finished shape, it is advisable to make trial cuts on material of the same thickness, using the same nozzle as will be used in the cutting operation. The width of the kerf produced on the trial cut is then used as a standard in laying out the line on the templet base.

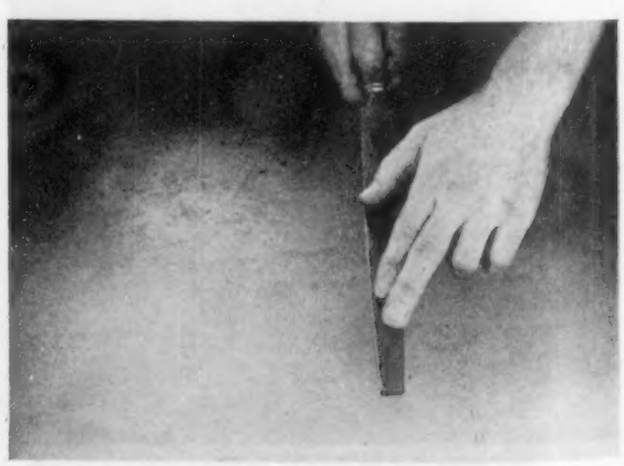


Fig. 14—Turn the Base Plate Over and Remove Any Burrs from the Drilled Holes

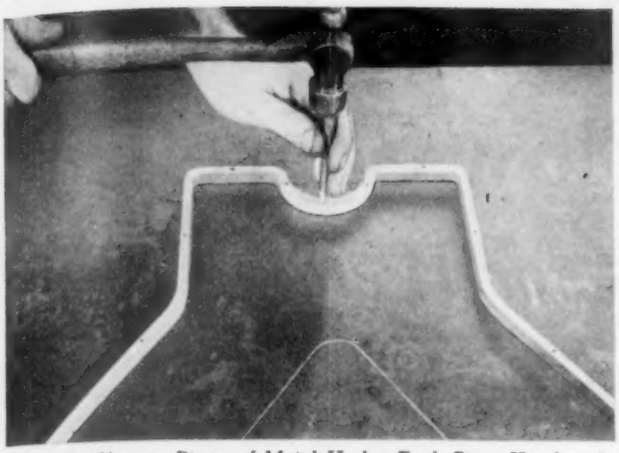


Fig. 15—Place a Piece of Metal Under Each Rivet Head and Expand the Rivet End with the Punch

Since the drive trunnions or guide rollers of the tracing unit have a fixed center-to-center distance, it is necessary to round the corners of the layout line, using a $^1/_4$-in. or $^5/_{16}$-in. minimum radius.

Forming the Templet Strip

For purposes of illustration, assume that a strip templet is to be formed to the design shown in Fig. 4 which illustrates the layout lines for both a shape and a hole scribed on a base plate. The base plate should be placed on wood or some other suitable support for drilling. There should be plenty of space around the work.

It is best to form the entire templet from one piece of strip. Standard strip material is usually obtained in 12-ft. lengths. Cut a piece of templet strip $^1/_4$ in. longer than the entire length of the layout line. Plan to have the joining of the two ends occur in a straight section. Start forming the strip near the center and work toward one end.

Easy curves can be formed by hand. Make the first curve as shown in Figs. 5 and 6 so that the outside curve of the strip will line up with the layout line. Then, as shown in Fig. 7, drill a hole through the templet strip and the base plate, using a No. 26 twist drill and the pilot drill block. The drill should be dipped in kerosene occasionally or in the white lead and machine oil mixture. Drill two more holes in the positions shown in Fig. 8 and, as each hole is drilled, place a rivet temporarily in it.

Use the bending tools to form the next curve (see Figs. 8 and 9). The tools should be placed over the templet strip so that the flat surfaces at the bottom of the tools rest squarely against the base plate. The bending should be done with one tool only, while the other is held firmly in place. When the sharp bend has been completed, drill another hole about halfway between it and the next one and insert a rivet in the hole. Then make the next sharp bend, holding the left-hand tool firmly in one position and using the right-hand tool to form the bend, as shown in Fig. 10.

Continue in the same way to the end of the templet strip. Drill rivet holes and insert rivets temporarily every 6 in. on easy curves and straight lines, and somewhat closer on sharp curves. Return to the original starting point and form the other half of the templet in the same way.

Attaching the Templet Strip

When the entire templet strip has been formed to the layout line, the ends should overlap somewhat. Carefully mark the end of the strip and use a hacksaw to cut off the overlapping end, leaving enough material for the ends to be filed square to form a tight joint (see Fig. 11).

If the templet is to be used with the Oxweld Type CM-15 Shape-Cutting Machine, use the templet-strip gage to check the width at all points (see Fig. 12). The strip may have thickened somewhat at the bends. Mark the points on the strip where the gage will not pass and remove all the rivets. Lightly file the marked areas, as shown in Fig. 13, until the gage will pass. Do not remove too much metal. Use a half-round file to file the inside of the curves.

Lay the formed templet strip aside carefully and follow the same procedure to form the templet for the hole.

Remove any burs from the drilled holes from the bottom of the templet strip and also of the base plate (see Fig. 14). With the templet strips in their original positions, check them for high points and for square contact with the metal base.

Insert the rivets from the underside of the base plate up through the templet strip. Place a flat piece of metal under each head and firmly pressing the strip against the plate, expand the ends of the rivets with a riveting punch as shown in Fig. 15. Be careful not to expand them too much.

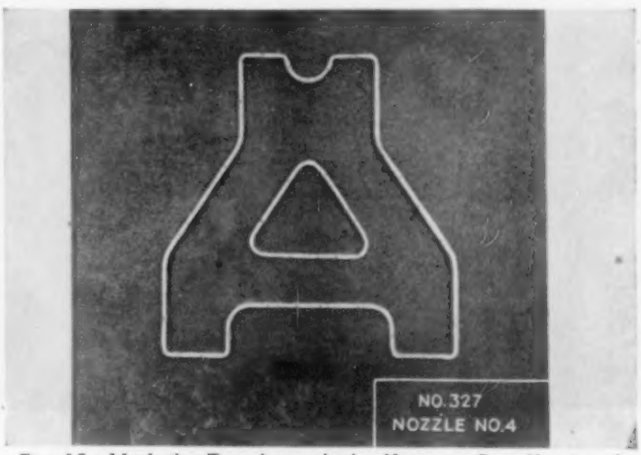


Fig. 16—Mark the Templet with the Name or Part Number It Is to Be Used to Form, and with the Nozzle Size

Recheck the templet strip for high spots and for squareness with the base plate. Lightly file the tops of the rivets so that they do not protrude. As suggested in Fig. 16, mark the templet with the name or part number it is to be used to form, and also with the size of the nozzle to be used with it.

Care of Templets

Every effort should be exerted to conserve the templets now in use. They should not be left where they can be damaged or destroyed. They should be protected from dirt and weather.

An efficient method of storing templets is to place them in a rack made of wood, angle iron or channel iron, located near the cutting machine. By cutting a hole or slot, in the templet base, the templets can be hung in orderly rows from an overhead beam in the rack. This method of storing templets lessens the danger of injuring them by handling, and makes it easy to find the right one for a particular job.

The use of worn templet strip material by turning it over is not recommended. Usually the removal of rivets will damage the strip, and the rivet holes will be enlarged. The bottom of the strip (formerly the top surface) would not rest squarely on the base plate, so that the templet would not be true; the narrow bearing surface might cause the strip to bend outward at sharp curves.

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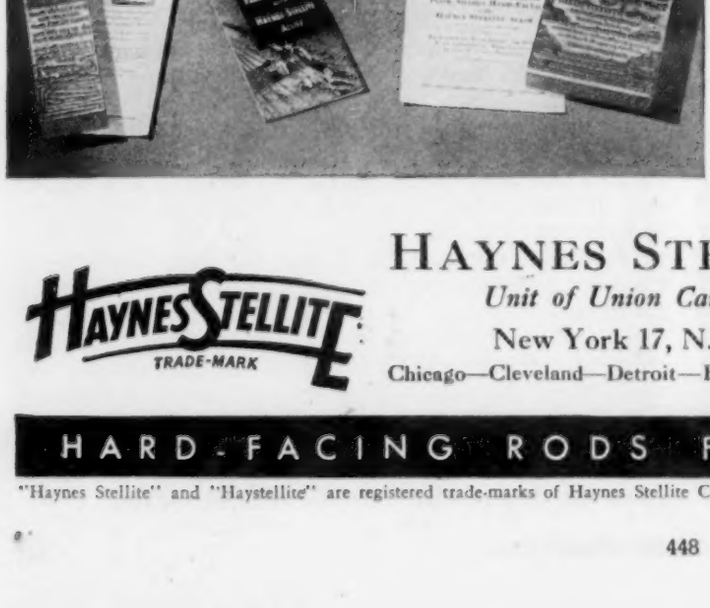

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Low-Temperature Joining*

By R. D. Wasserman† and Clinton E. Swift†

YOU are all familiar with the old methods of joining metals by soldering, brazing and fusion welding. These processes are well established in all metal fabrication shops and were a vital step in the production of the machines and materials of war supplied to our fighting men and our fighting allies. Supplementing soldering, brazing and fusion welding in many shops was low-temperature welding which offered its users the advantages of all three of the older methods of metal joining without many of their disadvantages. The widespread and still increasing use of the process is proof of the help it has been to industry during this national crisis.

The advantages of brazing which have been acknowledged for a great many years inspired the research work which resulted in the development of the low-temperature welding process. When brazing, joints with good strength were obtained at temperatures below the melting point of the base metal. The objections to brazing were usually that the weld metal was quite different in composition from the base metal which meant differences in many physical properties, corrosion resistance and color. A metal joining process, therefore, which would possess the advantages of brazing, but accomplish the same or better results with a bonding alloy or weld metal similar to that of the base metal, was thought to be the answer. Accordingly, a research program was established to accomplish this result.

It was realized, first of all, that special welding alloys would have to be developed for each general type of base metal, such as ferrous, copper, nickel, zinc and magnesium alloys. Fundamental studies were made, then, to determine the affinity of various metals for each other, and filler rods were created which, besides containing largely the components of the alloy they were designed to weld, also contained those metals which had a particularly strong affinity for the metals in the parts being joined. Then fluxes were developed which would act much in the manner of a catalyst, reducing surface tension of the weld metal, preventing oxidation of the base metal and aid in alloying the weld metal with the base metal. Further, the fluxes were compounded to melt and become fully liquid and active at the proper temperature to apply the welding rod to the base metal, thus eliminating any guessing about the temperature at which to supply the weld metal.

*Presented at the Twenty-Fifth Annual Meeting, A.W.S., Cleveland, Ohio, Oct. 16 to 19, 1944.

†Manager and Assistant Manager, Respectively, Engineering and Research, Eutectic Welding Alloys Co.

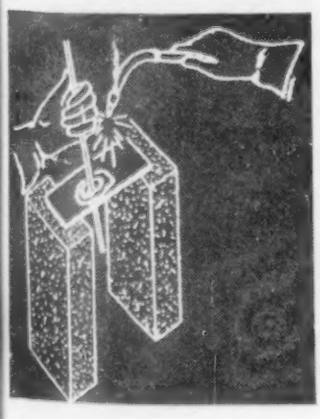

Fig. 1—Eutectic Alloying Penetration of Copper Plate by an Aluminum Alloy 800° F. Below the Melting Point of Copper

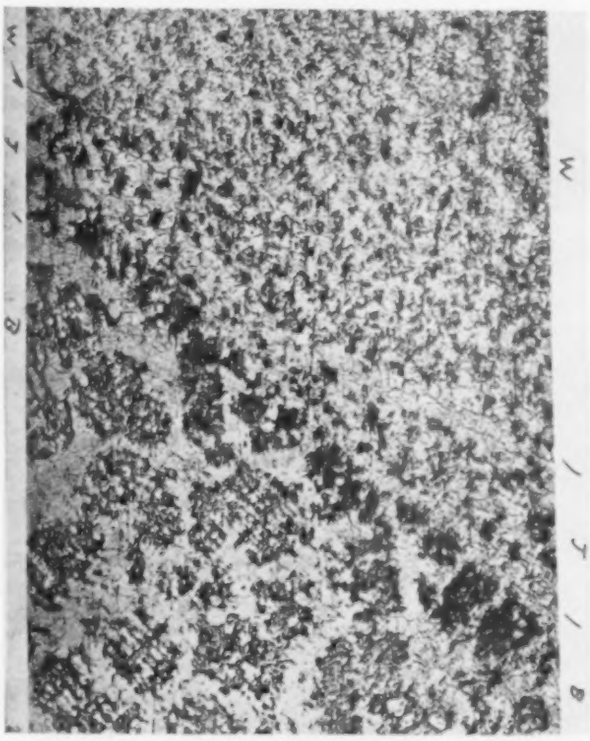

Fig. 2—Photomicrograph of Junction Between Cast-Iron Weld Metal and Base Metal. 500 ×

When these rods and fluxes were used on the base metals for which they were developed, it was possible to obtain a bond between the liquid weld metal and the solid base metal as accomplished in brazing, but with a tremendous added advantage. The weld metal was predominately the same alloy as the base metal!

How this is accomplished is easy to demonstrate and why we call the joints obtained "welds" will be shown. The technique for low-temperature welding is quite similar to that for bronze welding or brazing—the parts must be cleaned, coated with flux and heated. At the proper temperature, indicated by the melting of the flux, the rod is applied without melting of the parent metal. But here the similarity ends. As the molten weld metal is deposited on the surface of the still solid base metal which has been properly conditioned by the special flux used, it penetrates the surface of the parent metal, creating a thin film of a new alloy of a eutectic nature. As this thin film of eutectic alloy is saturated quickly by the base metal, it soon approaches that in composition and quickly solidifies to form a strong bond between the weld metal and the base metal. Photomicrographs show a continuity of grain structure from the parent metal, through the fusion zone to the weld metal to indicate that the phenomena described actually occurred. Thus,

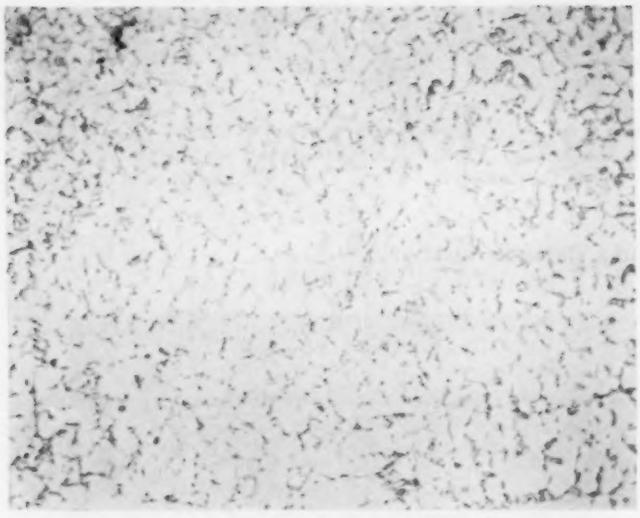

Fig. 3—Photomicrograph of Junction Between Aluminum Weld Metal and Cast-Aluminum Base Metal. 50 ×

what is metallurgically defined as a weld has been obtained with a procedure technically defined as brazing—we call it low-temperature welding.

A simple experiment with two metals will vividly demonstrate the principle of eutectic alloying. Copper and aluminum, though not commonly welded together, have a great affinity for each other as the low-temperature welding rods have for the base metal for which they are designed. A $^1/_{16}$-in. copper sheet with a melting point of 1980° F. is supported at each end and coated with a flux which will prevent oxidation of both copper and aluminum, This plate is then heated until the melting of the flux indicates that it is approximately at 1000° F., or just below the melting point of aluminum. An aluminum rod is held vertically over the copper plate and pressed firmly on it. The temperature is increased slightly until the aluminum rod begins to melt and then the copper plate is held at this temperature, some 800 or 900° below its melting point for 5 to 10 sec. Because of the great affinity of aluminum for copper, an aluminum-copper eutectic alloy is quickly formed. It consists of 67% aluminum and 33% copper and has a melting point

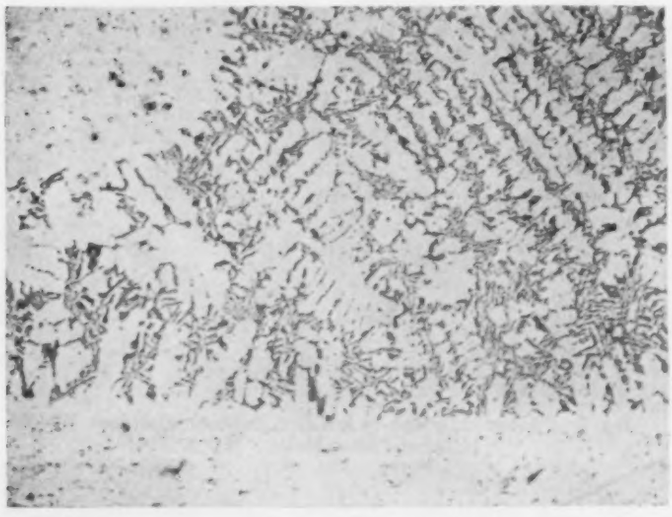

Fig. 4—Two Pieces of 2S Aluminum with About 0.010-In. Clearance Joined with a Thin-Flowing Aluminum Alloy. 100 ×

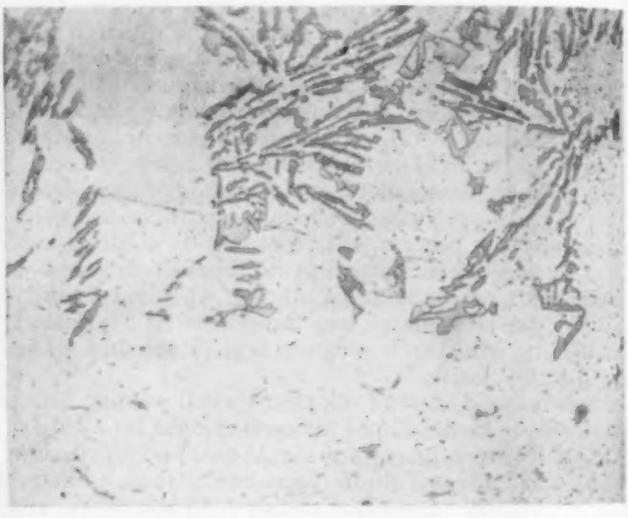

Fig. 5—A Detail of Fig. 4 Showing Alloying of Aluminum Weld Metal with the Base Metal. 500 ×

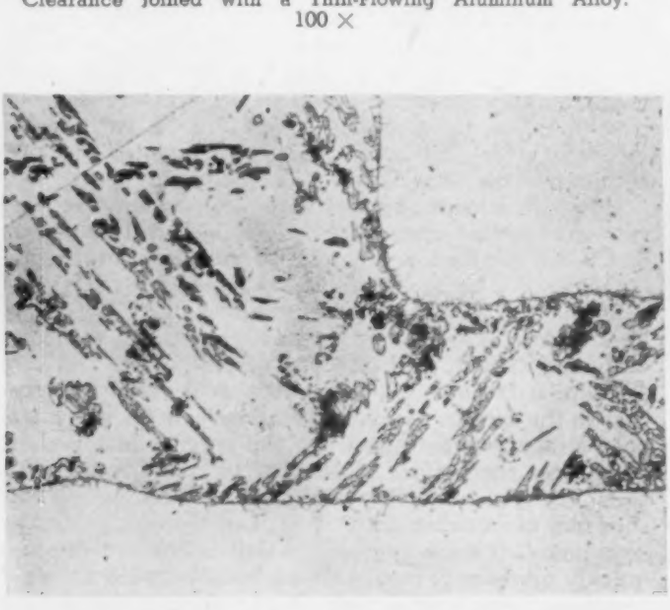

Fig. 6—Two Pieces of 2S Aluminum with About 0.010-In. Clearance Joined with a Thin-Flowing Tin-Base Solder. 100 ×

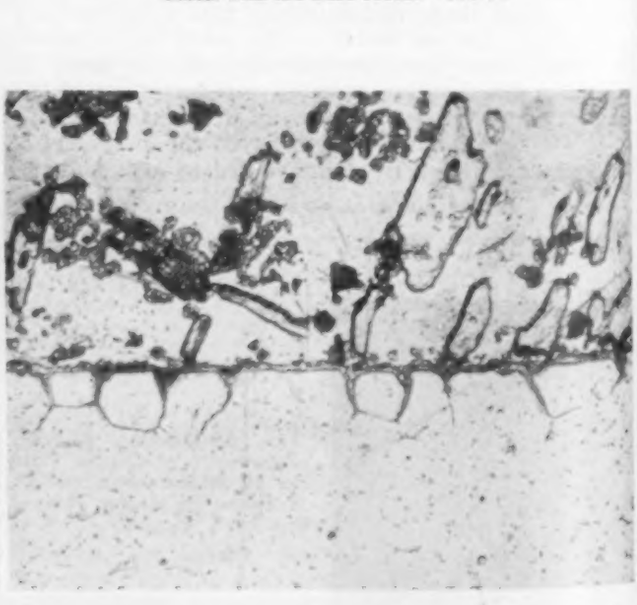

Fig. 7—A Detail of Fig. 6 Showing the Penetration of the Thin-Flowing Tin-Base Solder Into the Aluminum Sheet. 500 ×

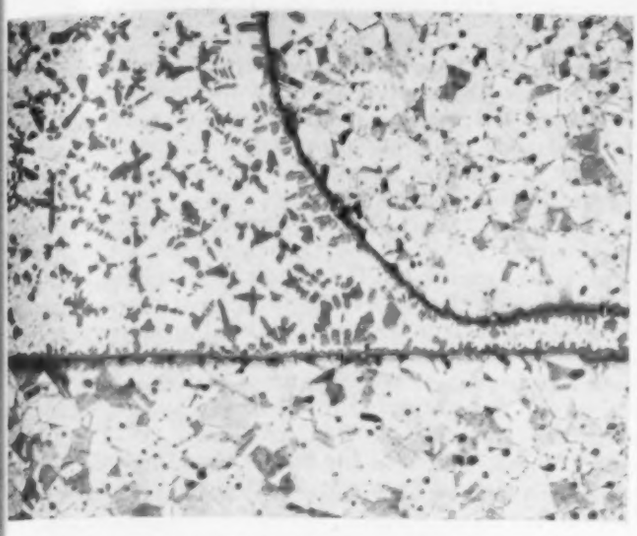

Fig. 8—Two Pieces of Extruded Brass with About 0.002-In. Clearance Joined with a Thin-Flowing Silver Copper Alloy. 100 ×

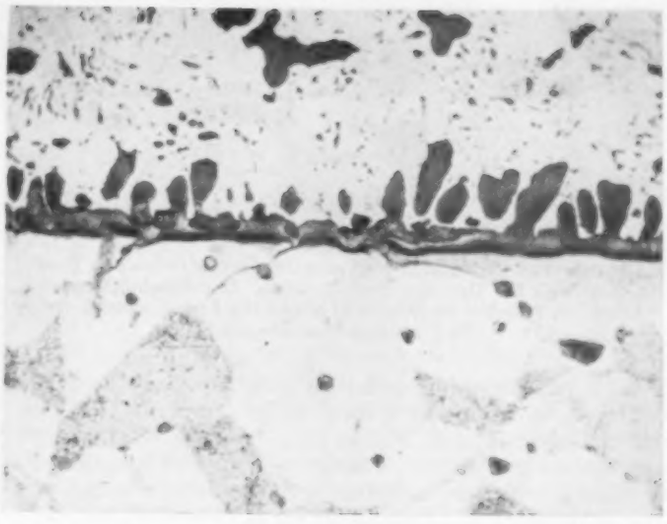

Fig. 9—A Detail of Fig. 8 Showing the Surface Alloying Between a Thin-Flowing Silver-Copper Alloy and the Extruded Brass Base Metal. 500 ×

of only 1018° F. As the copper plate is being held at a temperature slightly higher than this, the aluminum rod is quickly pushed through the molten pool of this eutectic alloy to form a sharp round hole through the copper sheet. This principle of surface alloying between a liquid weld metal and still solid base metal is the principle of low-temperature welding.

Joints made at low temperatures using a filler metal with a composition similar to the base metal have many advantages. The low temperatures used minimize distortion and stresses which cause cracking in brittle metals, or buckling and warping in those that are more ductile. Many joints are accomplished at temperatures below those that may affect the metallurgical characteristics of the base metal. Because the weld metal is similar to the base metal in composition, it has similar physical properties, equal corrosion resistance and is an actual color match. Such joints have good strength and are free from porosity.

There are two basic types of low-temperature alloys available. Because the temperature range at which they are applied varies so widely, it has been confusing to call the alloys welding rods, brazing alloys or solders, as few of them are fully described by this established terminology. We have, therefore, divided them into two groups according to the basic procedures by which they are used. There is the bead-forming type, which is used in beveled-butt joints, fillet welds or as overlays, in which the welding technique is similar to fusion welding or bronze welding, but accomplished at lower base metal temperatures. The thin-flowing type describes all those that are used in lap or square-butt joints, and which flow into such joints by capillary action, similar to the established technique of brazing, silver soldering or soft soldering.

Not all of the low-temperature welding alloys produce true low-temperature welds. When certain of the bead-forming or thin-flowing alloys are used on greatly dissimilar base metals, such as copper-zinc alloys on cast iron, or silver-copper alloys on steel, brazed or silver brazed joints are obtained. The affinity, however, of these joining metals for the base metals on which they are used has been increased by the addition of small amounts of certain metals known to have a special affinity for the base metal for which they are recommended.

A number of photomicrographs, at different magnifications, have been made to show the alloying that has taken place between both the bead-forming and thin-flowing type of low-temperature alloys as applied to various base metals. Figure 2 is a photomicrograph of a joint made

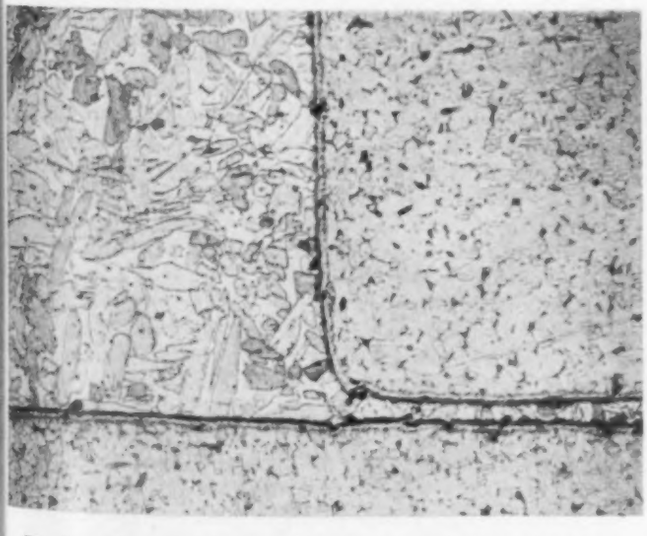

Fig. 10—Two Pieces of Cold-Rolled Steel with About 0.001-In. Clearance Joined with a Thin-Flowing Copper Alloy. 100 ×

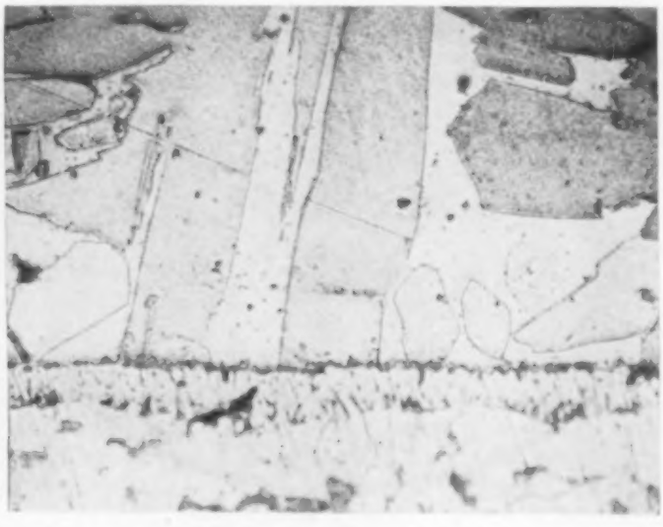

Fig. 11—A Detail of Fig. 10 Showing the Intimate Bond of This Copper Alloy to Steel. 500 ×

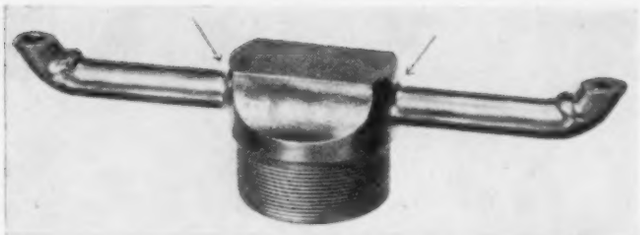

Fig. 12—The Production of Hydraulic Jack Manifolds Is Simplified with the Use of a High-Strength, Thin-Flowing Copper Alloy. It Was Not Necessary to Screw the Parts Together and No Finishing Was Required

with a bead-forming cast-iron alloy applied to an ordinary iron casting at a base metal temperature which did not exceed 1400° F. In fact, bonding will occur at base metal temperatures ranging from 950 to 1400° F. to make a joint which will develop as much as 48,000 psi. The continuity of grain structure is clearly shown, and only a very narrow line of the eutectic alloy remains to indicate how the joint is accomplished. This joint exhibits all the requisites of a true weld.

In Fig. 3, where a bead-forming aluminum alloy was used on an aluminum casting, it is almost impossible to discern the eutectic alloying line, even though the weld metal was deposited at a base metal temperature approximately 200° below the melting point of the casting, from 950 to 1075° F. Tensile strengths as high as 29,000 psi. will be developed.

The photomicrographs in Figs. 4 and 5 show the use of a thin-flowing aluminum alloy on rolled aluminim. This alloy flows on sheet aluminum like silver solder on brass, at a temperature at least 150° below the melting point of the sheet. Yet, here is indisputable evidence that the thin-flowing weld metal has completely alloyed with the base metal to form a true low-temperature weld. This bonding occurs at temperatures from 950 to 1040° F. and the joints develop 30,000 psi.

Figures 6 and 7 are photomicrographs showing the application of a very recently developed tin-base solder which, with the flux developed for it, will flow thinly on aluminum, and may even be used to join aluminum to other metals such as steel, copper or nickel alloys. Even though this alloy is applied at a temperature of only 400° F., and would technically be called a solder, yet here is evidence of the beginning of surface alloying, or at least a definite penetration of the solder into the surface of the rolled aluminum. This intimate bond accounts for the high shear strength of 5000 psi. obtained when using this alloy on aluminum.

Fig. 13—An Aluminum Casting Is Salvaged with a Welding Rod Applied Without Melting the Base Metal

A silver-copper alloy used on leaded brass is shown in Figs. 8 and 9. This thin-flowing metal formed a surface alloy with the base metal at a temperature approximately 500° below the melting point of the brass, from 940 to 1140° F. Depending on the base metals used, the length of joint and clearance provided, tensile strengths from 52,000 psi. to shear strengths of 120,000 psi. are obtained with this thin-flowing alloy.

Figures 10 and 11 show an application of an unusually high-strength copper alloy which is both a thin-flowing and bead-forming rod for use on steel and all its alloys. The alloying elements in this rod have been selected to provide an extremely strong bond to the ferrous base metals as is shown in these photomicrographs. It bonds to steel at base metal temperatures of 1300–1600° F. and begins to flow thinly at 1675° F. In square-butt joints with as much as 0.020-in. clearance, it will develop 117,000 psi., and with the proper clearance in lap joints, it will show shear strengths from 150,000 to 180,000 psi.

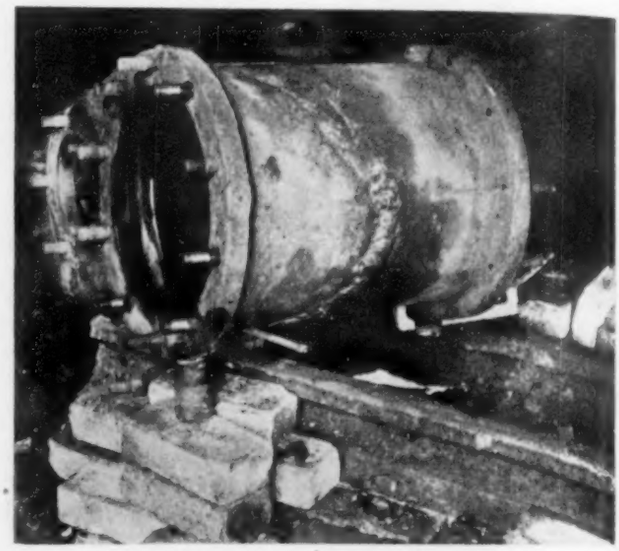

Fig. 14—A Cast-Iron Cylinder of a Steam Engine Is Repaired with a Cast-Iron Welding Rod Applied at a Base-Metal Temperature Which Did Not Exceed 1400° F.

In the photomicrographs just discussed, we have shown that at base metal temperatures varying from 200 to 800° below their melting point, joints are obtained with low-temperature welding alloys that have every appearance of being welds. We believe it is agreed that the indication of a weld is the continuity of grain structure through the fusion zone to a weld metal that is substantially the same as the base metal. This has been demonstrated to be the type of joint obtained with the application of certain of the low-temperature welding alloys in beveled-butt joints, and others in lap joints where they have been drawn between the lapped surfaces by their capillary action and then instantly alloyed with the base metal. In other cases, we have shown that where the thin-flowing alloy and the base metal are widely different, something more than a brazed joint is accomplished because of the unusual affinity of these thin-flowing alloys for the base metals on which they are used. Illustrations of completed joints show the wide field of application of this process, although it is difficult at a glance to appreciate the saving in time and heating that was obtained through the use of the low-temperature welding process. However, the welders and operating departments of plants which are using this process appreciate the great savings in time and material, and the machining and finishing departments find little further work to do on assemblies that have been fabricated in this way.

The fields of application for low-temperature welding are briefly cited:

A. Production Welding

1. When the harmful effects of high temperatures must be avoided, particularly warping, distortion, residual stresses or metallurgical damage to the parent metal.

2. Where joints with the absolute minimum of excess metal are required in order to save costly machining or finishing.

3. When fusion welding or brazing is inadequate, the low-temperature bead-forming or thin-flowing alloys will often be the solution. The sizes of the parts which can be joined with thin-flowing alloys are unlimited, except that means must be available to heat entire joints uniformly and rapidly.

B. In Salvage

1. Defective castings or faultily machined parts can be salvaged because the weld is a perfect color match and can be made at low temperatures. The advantages of the process in this field are obvious.

C. Repair Welding

1. The wide range of rods for different jobs on each base metal proves it to be unquestionably the best method for maintenance welding because of the great variety of sizes, shapes and metals encountered in this kind of work.

The low temperature of application and the great strength obtained, combined with the fact that distortion is minimized and the base metal remains unaffected, make it a necessary welding tool for every maintenance welder.

Discussion by A. M. Setapen*

The authors are to be congratulated for presenting a paper on a subject of timely interest since welding and brazing alloys have been used in ever-increasing quantities in war production.

There is no question that it is possible to prepare a eutectic composition of two metals having widely different melting points by heating the charge above the melting point of one but below that of the other, as illustrated by the authors in the aluminum rod and copper sheet experiment. However, it appears that the factors acting in this case are quite different from those that take place when making a joint of two members using a filler rod. Since time is a definite function of alloying or diffusion, it is difficult to see how it is possible to get any alloying of the filler metal with the base metal, when the base metal is held several hundred degrees below the flow point of the filler metal, in the very short period of time required to make the joint.

In addition, in the case of using the so-called thin-flowing alloys where very small clearances of joint (0.0002–0.004 in.) are most suitable, it is difficult to see how the filler metal can penetrate the entire joint area without solidifying if the base metal temperature is well below the flow point of the filler metal when one considers the relative masses of the materials being joined compared with the filler material. My personal experience has been that when a brazed joint is made where the base metal is not heated to the flow point of the filler alloy the resultant joint strength is very low.

The authors failed to point out that the method of heating the base metal to a given temperature below the temperature to flow the filler alloy is not applicable when the preplacement technique of applying the filler alloy is employed. In other words, their method of low-temperature joining cannot be used with furnace, resistance and induction brazing or any other method of brazing where it has been found advantageous on high production applications to preplace the brazing alloy.

Finally it would be of considerable interest to a number of readers if the authors included a list of brazing alloys giving their composition, melting and flow points, particularly in those cases where illustrations were given.

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Authors' Reply

We have apparently failed to make clear to Mr. Setapen in our paper that there are two entirely different types of "low-temperature welding" alloys. We refer to them as "bead-forming" and "thin-flowing" alloys. As stated in the paper, the "bead-forming" type is used in beveled-butt joints, fillet welds or as overlays with a welding technique similar to fusion welding or bronze welding, except that the base metal is not heated to its melting point, nor necessarily to the melting point of the weld metal. The "thin-flowing" type of alloy is used in lap or square-butt joints, and flows by capillary action, similar to established procedures for brazing, silver soldering or soft soldering.

When "low-temperature welds" are made with welding rods similar to the base metal such as cast iron on cast iron, bronze on bronze or aluminum on aluminum, alloying between the weld metal and the base metal is accomplished by the formation of a "eutectic" alloy on the surface of the base metal to which the weld metal instantly bonds. This "eutectic" alloy is formed from metals in the welding rod and possibly one or more metals deposited on the surface of the base metal by the flux. This "eutectic" alloy is molten at the "bonding temperature" or base metal temperature required to effect a bond or surface alloying between the molten weld metal and the still solid base metal. The "eutectic" alloy formed is established in a thin film, perhaps only 0.001 in. thick or less, and it is so rapidly alloyed into the base metal and the weld metal that its presence is even hard to detect in photomicrographs, although slight variations in the structure along the interface, between the weld and base metal, indicate that there is a slight difference in composition along that line.

We want to make clear that it is possible to take advantage of this "eutectic" alloying phenomena *only with the "bead-forming" alloys*. While most of the "thin-flowing" alloys may be applied by this process, their general use in lap or square-butt joints, into which they flow by capillary action, requires that the base metal be heated to the melting or flow point of these alloys. Often after the "thin-flowing" alloys have been drawn into lap or square-butt joints by capillary action, "eutectic" alloying takes place which increases the strength of the bond between the weld metal and the base metal. This is particularly true where "thin-flowing" or brazing alloys similar in composition to the base metal are used, such as in the use of silver-copper-zinc alloys on brass and low-melting aluminum alloys on aluminum.

Mr. Setapen points out that a definite element of time is required to effect alloying between weld metal and base metal when the base metal is at a temperature well below its melting point. In this, he is entirely correct, but this period of time is shortened to a few seconds when "eutectic" alloying action is promoted by the addition of other metals to the surface of the base metal by the flux, for instance.

When the "thin-flowing" alloys are used by any process, that is, when they are applied with the torch, or when the work is heated by electrical resistance or induction

processes, or in a furnace, the base metal temperatures required are equal to or in excess of the melting points of these alloys.

Mr. Setapen states that it would be of interest to a number of readers to have the composition, melting and flow points of the brazing alloys referred to in this paper. While he did not specifically request information on the "bead-forming" alloys, it might be of interest to state that the compositions of the cast-iron and aluminum welding rods referred to in this paper are only slightly different from those commonly used for fusion welding cast iron and aluminum. Their ability to bond to the base metal at temperatures below the melting point of the base metal is obtained through the addition of very small amounts of one or two other metals to the welding rod, or by the deposition of other metals on the surface of the base metal by the flux.

The "thin-flowing" alloys used are likewise similar to alloys generally used for this type of work. In addition to the usual major elements, small amounts of other metals have been added to these alloys to improve their thin-flowing properties or capillary action, and increase their affinity to the base metal. Fluxes used with these alloys are an integral part of their successful application, as they add small amounts of metals to the surface of the base metal and further improve capillary flow and the alloying of the brazing alloy with the base metal. The major constituents of the alloys discussed in this paper are as follows:

Welding Rod for Cast Iron (Fig. 2)

Iron	90–92%
Total carbon	3–5%
Silicon	3–5%
Other metals	Balance

Alloy for Welding Aluminum (Fig. 3)

Aluminum	90–95%
Silicon	3–6%
Other metals	Balance

Alloy for Welding Aluminum (Figs. 4–5)

Aluminum	85–90%
Silicon	6–15%
Other metals	Balance

Alloy for Soldering Aluminum (Figs. 6–7)

Tin	48–52%
Lead	28–34%
Zinc	18–24%
Other metals	Balance

Silver Brazing Alloy (Figs. 8–9)

Silver	56–60%
Copper	20–24%
Zinc	15–19%
Other metals	Balance

Brazing Alloy (Figs. 10–11)

Copper	44–52%
Zinc	40–46%
Nickel	8–14%
Other metals	Balance

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(*Continued on page 470*)

Determination by Statistical Analysis of Process Minimums for Spot Welding

By Harold Robinson*

Abstract

This paper describes a statistical procedure which is designed to account for the inherent variability of a given process (e. g., spot welding) in establishing process minimums. The use of this method provides a minimum and measurable risk against the process falling below specification quality. In order to use the procedure outlined in the following pages, certain requirements must be met.

1. The control specimens must be representative of the process. Random check specimens must be random.
2. The process must be in a state of statistical control as shown by the control chart.
3. The standard deviation must be determined for the process over a reasonably long period of stability or control.

These requirements will be discussed in more detail in the body of the paper.

Introduction

THE use of statistical methods has become so widespread and has made such rapid advances in the production and inspection branches of modern engineering in the last few years that no introduction should be necessary. The process is rare that cannot be improved from both a quality and an economical consideration by the application of statistical analysis. Within the next few years, it is felt that there will be few manufacturing processes to which statistical methods will not be applied in some form.

To those who prefer "common sense" or "intuition" it can be argued that *statistical analysis* is common sense systematized and quantitatively expressed. It is not true that if 100% inspection is required, then statistical analysis cannot be applied. Unless 100% inspection efficiency can be realized, which is seldom the case, 100% inspection alone is not enough but should be supplemented by statistical control.

The statistical method makes possible the expression of the variability of a process in quantitative terms. The ability to describe a phenomenon in measurable units is the first step in any scientific or engineering analysis. Once a method is presented for expressing variability in quantitative terms, the procedure for controlling a process becomes a mechanical one.

In the January 1944 issue of THE WELDING JOURNAL,[5] N. C. Clark has presented a rather complete picture of spot welding, the causes of variability and methods for measuring, expressing and controlling this variation. This article is a necessary introduction to the views to be expressed in this paper.

It will have to be assumed in the following discussion that the reader is at least familiar with the fundamentals of statistical methods. These fundamentals can be easily obtained by referring to one of the several listed references. Considerably more study will be necessary to follow the rigorous mathematical proofs and derivations which form the background of statistical analysis. However, it is not necessary to master the basic mathematics of statistics in order to use it successfully.

For convenience, a very brief and simplified review of the nature of statistical methods as applied to the subject of this paper is given (without proofs) in the Appendix.

Reason for Process Minimums

It should be apparent that if the product of a process is to be kept above a certain specification or design minimum value, the average value of the product must be kept considerably above this specification minimum in order to insure that the greater percentage of the values of the distribution will fall above the specification minimum. But how far above the specification minimum must the process average be in order to insure a minimum number of parts from falling below specification minimum, and exactly what risk will the producer be taking against the process falling below the agreed upon quality? One approach toward the solution of these questions will be presented in this paper.

Since 100% inspection of spot welds is neither economically possible nor structurally necessary, some sort of sampling system must be designed to provide a minimum risk against spot welding below the desired quality. It should be constantly kept in mind that just so long as a sampling system (less than 100% inspection) is used, it is impossible to guarantee quality 100%. The consumer† must realize this and be willing to cooperate to the extent that he is willing to accept quality of some small percentage below specification value.

So far as the designer is concerned, only the minimum strength of the spot weld is important. This paper will not go into the metallurgical features which might determine the maximum strength desirable in spot welds. It should be emphasized that the determination of minimum values by statistical analysis in no way precludes the necessity for controlling the metallurgical quality of spot welds such as freedom from cracks, excessive porosity, proper nugget penetration or the elimination of any types of defects which can be shown to be detrimental to the strength or fatigue life of the welds. In fact, it will probably be necessary to control these points before statistical control can be realized or in order to reduce further the variability of the process. A good deal has already been written on this subject and it will serve no purpose to repeat.

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† The term consumer is used in a general sense. Producer and consumer may represent different departments of the same company.

Procedure for Setting Up a Welding Machine

The operational procedure for "setting up" a machine is very simple. Before welding a part, the operator will make the necessary machine adjustments and proceed to weld a sample consisting of a predetermined number of shear specimens.‡ The average of the shear strengths of the specimens in the sample shall be equal to or above a value which will be called the *Process Minimum*. If the average is below the process minimum, readjustments will be made in the machine and a new sample taken. The process minimum is determined by the welding or quality control engineer at periodic intervals based on the control chart data either by direct calculation or the nomogram suggested in this paper.

If the tips have just been cleaned, it is suggested that several spot welds be made before taking the sample. Hess has shown that there is no correlation between weld strength and the order in which welds are made[6] and on this basis the first spot welds are a fair sample. However, the tip contour and tip pickup will change as welding progresses and result in a gradual change in shear strength. Here again, the welding engineer's knowledge of the process will have to determine the frequency of the sample.

Determination of Process Minimum

The determination of the process minimum is based on a controlled process as shown by the control chart and a normally distributed population. Reference will be made to Fig. 1 which is a graphical representation of a typical process which is normally distributed about its mean, $\bar{X}$.

A. Definition of Terms Used in Fig. 1

1. Tail Area, p_t.—This area to the left of the specification minimum (expressed in per cent of the total area under the distribution) is called the "lot tolerance percentage non-conforming." The area represents the per cent of spot welds whose shear strength can be tolerated to fall below the specification minimum in the long run. Values of p_t = 1%, 0.5% and 0.1% are suggested as reasonable. The nomogram is solved for these three tail areas. In other words, the consumer or designer will agree to accept the process and design accordingly if the quality for the greater per cent of the time does not become worse than the agreed upon per cent non-conforming.

2. Lot Tolerance Average $\bar{X}p$.—The "lot tolerance average" is the average value of the process which for a given standard deviation (σ) will give the tail area, p_t, as shown. If the standard deviation becomes smaller, the distribution will become narrower, permitting a lowering of $\bar{X}p$ in order to maintain a constant area, p_t and vice versa. If the standard deviation is fixed, the "lot tolerance percentage non-conforming" can be changed by shifting $\bar{X}p$ to the right or left.

3. Distribution of Means.—If instead of making a frequency distribution of single observations, rational subgroups of size, n, are selected and averaged, the distribution of these arithmetic means will have the same average as the average of individual observations, but the distribution will be somewhat narrower by the same amount that the standard deviation is reduced.

‡ The efficiency of this procedure depends in a large part on the degree in which the shear samples represent the spot welds which go into production parts. It is the duty of the welding engineer to design a shear specimen and procedure for preparing and handling these specimens to accomplish this purpose.

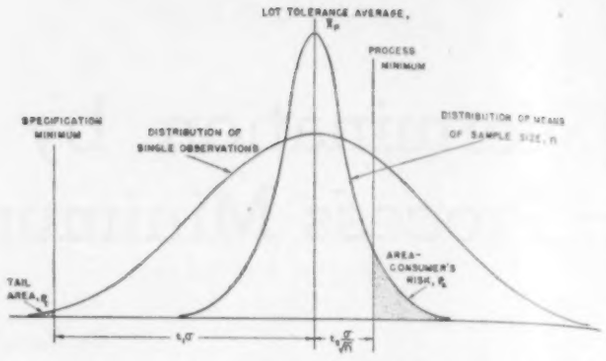

Fig. 1—Graphical Representation of a Typical Process

If the standard deviation of the distribution of single observations equals σ, the standard deviation of the distribution of means will equal $\sigma/\sqrt{n}$. The larger the sample size, the narrower the distribution of means.

4. Process Minimum.—This is the minimum value which the average of a sample size, n, may fall in setting up a machine before spot welding parts. This value has been mentioned in a previous section. The reason for its position with relation to the distribution is described under "Consumer's Risk."

5. Consumer's Risk, P_c.—The quantitative value of the consumer's risk is represented by the area, P_c, to the right of the process minimum in the distribution of means. For the sake of uniformity and convenience, the consumer's risk is usually set at 10%. The consumer's risk is the probability of accepting welding of quality $\bar{X}p$ with tail area p_t. In other words, suppose we have a priori information that the quality of the product is represented by the distribution whose average is $\bar{X}p$ and tail area p_t with the distribution of means as shown in Fig. 1. If we accept samples when they are equal to or above the process minimum and reject them the rest of the time, we will be accepting samples not more than 10% of the time in the long run even though the samples come from a distribution of quality $\bar{X}p$ with an acceptable tail area p_t. In nine cases out of ten, the producer will be rejecting samples if the quality is no better than the lot tolerance average. If the quality is better than $\bar{X}p$ ($\bar{X}p$ shifted to the right), the area P_c becomes greater than 10% which means the probability of acceptance becomes higher and vice versa. Figure 5 is the plot of the areas P_c vs. P_t when the process minimum is fixed and $\bar{X}p$ is shifted to the left. The curves are drawn for the three cases where P_c = 10%, p_t = 1%; P_c = 10%, p_t = 0.5%; and P_c = 10%, p_t = 0.1%. If the process remains fixed, and a lower consumer's risk is desired, a larger tail area, p_t, will have to be accepted. This can be observed by referring to Fig. 1 and imagining the distribution shifted to the left to reduce area P_c, which automatically increases area p_t. For a fixed consumer's risk of 10%, the process minimum may be lowered by taking larger sample sizes without increasing p_t or changing the process average. It should be noted that if $\bar{X}p$, σ, p_t and P_c are fixed, the process minimum will approach $\bar{X}p$ as a limit as the sample size increases. But by decreasing σ, the process minimum approaches the specification minimum as a limit, P_c, p_t and n remaining constant. So far as production is concerned, low process minimums are desirable. The most efficient way of accomplishing this is to reduce the variability or standard deviation. Less effective, but also desirable for other reasons, as shown by Fig. 5, is to increase the sample size. Reference 5 describes the factors involved in reducing the variability.

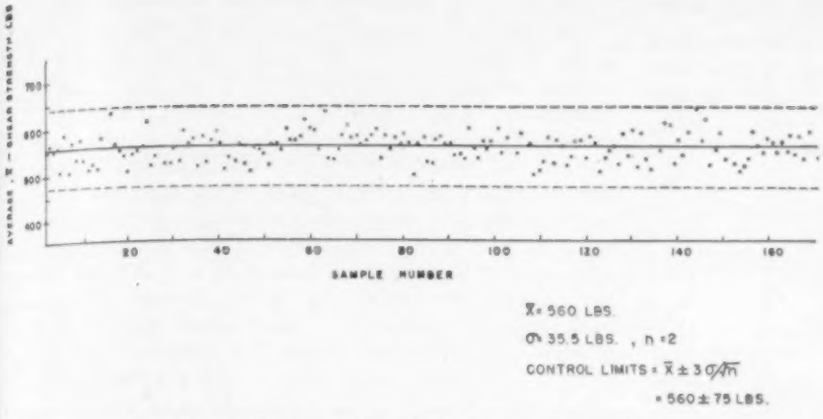

Fig. 2—Typical Control Chart Over Period of One Month

6. In summarizing, the following points should be clear.

The process minimum can be reduced when:

(a) P_c, p_t, $\bar{X}p$ and n are fixed by reducing σ, (process minimum approaches specification minimum as a limit).

(b) P_c, p_t, $\bar{X}p$ and σ are fixed by increasing sample size n (process minimum approaches lot tolerance average as a limit).

The tail area p, can be reduced when:

(a) P_c, n and $\bar{X}p$ are fixed by decreasing σ.

(b) P_c, n and σ are fixed by increasing $\bar{X}p$.

B. Assumptions and Requirements

Before any quantitative calculations can be made, there are certain conditions to meet and assumptions to make.

1. The random check specimens must be random! The subject of random sampling is beyond the scope of this paper. A little engineering judgment and knowledge of the process is usually sufficient to insure reasonably random sampling. At Republic Aviation, sampling is done by a random check inspector who at random intervals of about once every hour per welding machine takes sample shear specimens of the same material and gage combination being welded. No changes in machine settings are made prior to the sampling. The average of this sample should be plotted on a control chart. Necessary steps should be taken when points fall outside of limits.[5,6]

2. The process must be in a state of statistical control. This is very important. Statistical control is realized when variations in a process are due to a constant system of chance causes. When this is realized, the average $\bar{X}$ and standard deviation σ will become statistically stable and samples will be randomly distributed about $\bar{X}$. The criterion for statistical control is the well known control chart. The sample averages are plotted in a historic sequence on a horizontal chart about the average with plus and minus $3\sigma/\sqrt{n}$ limits. Points which fall outside of the limits are considered due to assignable causes of variation and the process is not in control. Reference 3 describes the control chart and the simple mechanics involved in carrying through the procedure. After assignable causes have been removed, and the control chart shows the process to be in control for a period of at least 2 weeks, or until about 300 points have accumulated, it is valid to apply statistical analysis in setting up process minimums. New process minimums should be determined whenever the control chart shows a significant change in the process average or standard deviations. Figure 2 shows a control chart which shows reasonable control over a period of about one month.

3. The distribution is approximately normal.§ This assumption is desirable in order to make possible the use of normal integral tables in determining the limits and probabilities. It is a fortunate coincidence that the assumption is reasonable if the process is in statistical control. Several frequency histograms were determined from random check data consisting of over 500 specimens. In every case where the control charts showed the samples to be in control, a normal curve was nicely fitted to the data, Fig: 3. There are other tests to apply for normality and in no case did the assumption of a normal curve appear invalid. The criterion of control, however, must be adhered to.

4. The standard deviation does not change with small shifts in process average. This assumption can be legitimately questioned if the shift in the process average becomes significant. Fortunately, the condition is almost self-correcting. If the process average is decreased, the variability or standard deviation will probably decrease. This will make predictions regarding the tail area conservative. On the other hand, if the tail area is too large and corrections necessary are in the direction of an increasing process average, it is possible that the standard deviation will increase, making the first increase insufficient. However, redetermining the standard deviation will probably call for subsequent small adjustments in the process average which should cause little change in the standard deviation.

§ Theoretically the distribution cannot be normal since the process is biased. The minimum shear strength cannot fall below zero but mathematically the maximum can approach infinity.

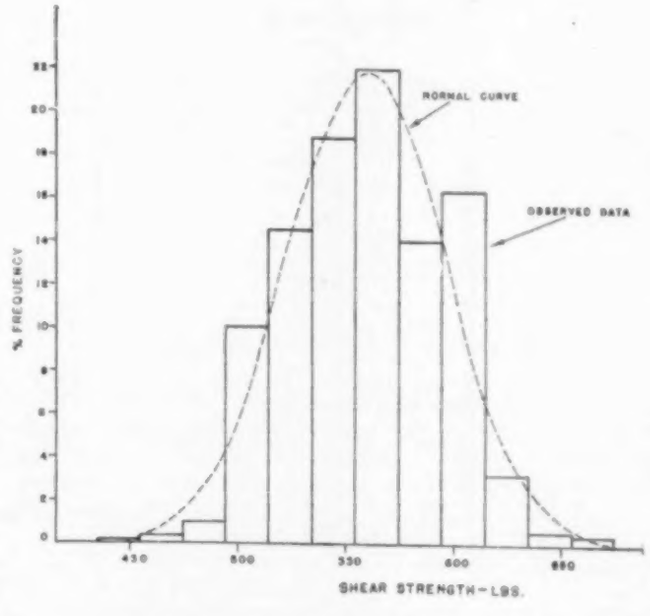

Fig. 3—Fitting Normal Curve to Data of Fig. 2

Frequency histogram. For Al 24ST, 0.040–0.040. Average, $\bar{X}$ = 560 lb. Standard deviation, σ = 35.5. Skewness, k = −0.010. Sample size, n = 570.

C. *Use of Nomogram to Determine Process Minimum*

Figure 4 is a nomogram calculated from normal integral tables for three different "lot tolerance percentage nonconforming," p_t = 1.0%, 0.5% and 0.1% for sample size from n = 2 to 10 and a consumer's risk of 10%. To use the nomogram it is necessary to know:

1. The standard deviation of the process for the particular gage combination over a reasonably long period of control.
2. The acceptable "Lot tolerance percentage nonconforming," p_t.
3. The sample size.**
4. The specification minimum.

** Statisticians will probably object, and with some justification, to the small sizes solved for in this procedure. However, those familiar with usual shop practices will be aware of the difficulties encountered in trying to obtain larger samples, especially in cases where it may be necessary to set up a machine for different gage combinations several times during a single shift. Even when a machine is welding one job continually, the author would suggest frequent small samples during the shift rather than a large sample at the beginning of each run.

The process minimum is found automatically.

The only calculation, in addition to the control chart, is the determination of the standard deviation, σ. The process average is found only as a necessary part of the calculation in determining the standard deviation. The standard deviation, σ, should be found directly from the data of *individual* observations which are used to plot the control chart and determined from not less than approximately 300 observations during a period which the control chart shows the process to be in statistical control. The σ determined from a sample of n = 300 will give an estimate of the variability of the process with a fairly high degree of precision. (If σ is determined from the plotted points directly from the control chart instead of from individual observations, the σ to be used in the nomogram should be multiplied by $\sqrt{n}$ where n is the size of the sample whose average was plotted on the control chart.) Though, in effect, shifting of the process minimum amounts to corresponding changes in the

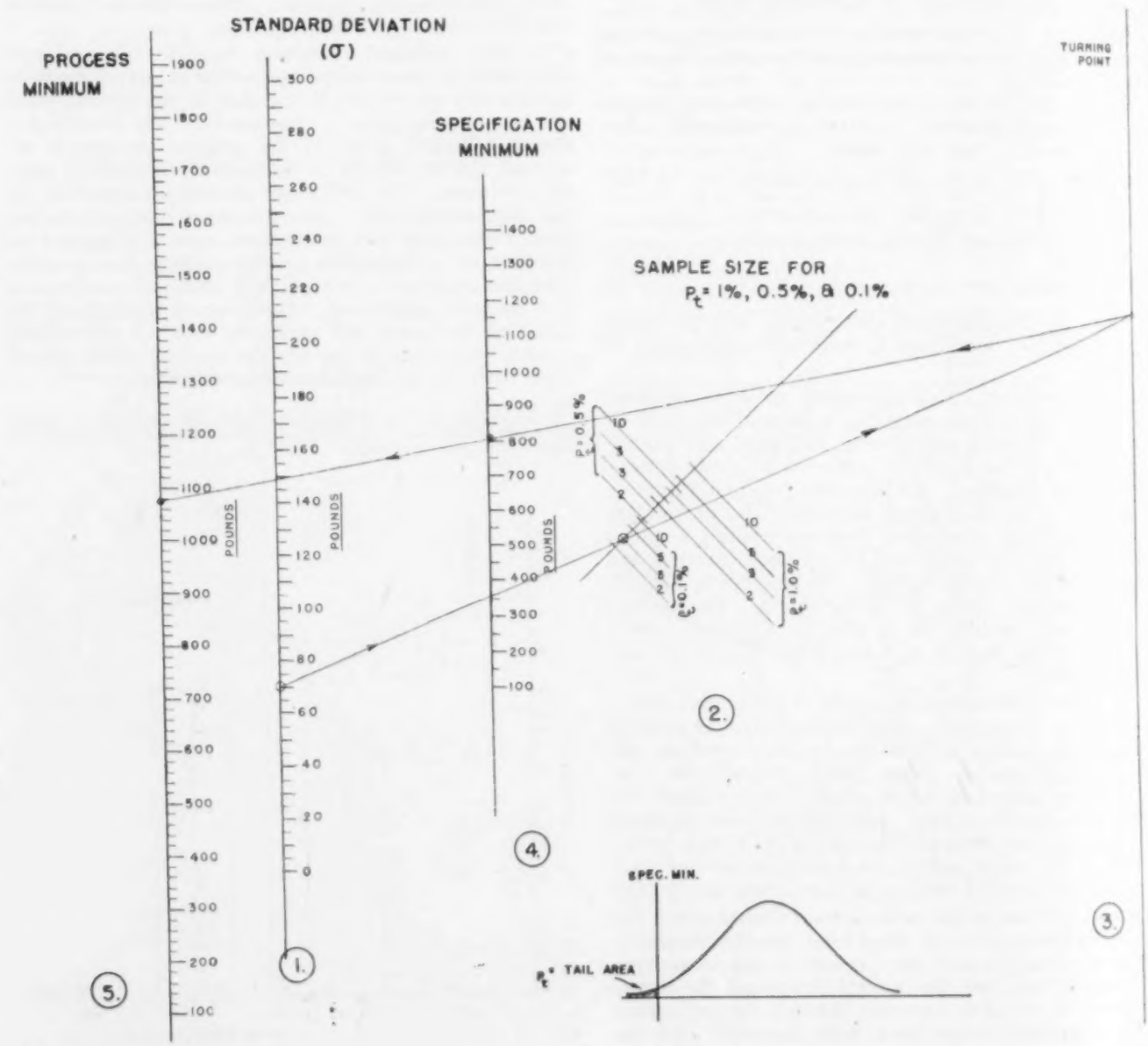

Fig. 4—Nomogram for Determining Process Minimums for Spot Welding

Sample solution for σ = 70 lb. Sample size, n = 3. Tail area, p_t = 0.1%. Specification minimum = 800 lb. Process minimum (from nomogram) 1070 lb.

process average, the process average is not used in the nomogram or subsequent charts. There is no reason why the nomogram cannot be solved in reverse to establish one's own design minimums based on what experience shows to be a safe process minimum.

D. Quantitative Determination of Risk

If the nomogram is used as directed, a natural question to ask is, "if the process is a higher percentage non-conforming than the selected value of p_t, just what are the chances of the sample average being equal to or greater than the process minimum as found by the nomogram?" In other words, "what protection against acceptance of subspecification quality is offered by this method?"

The answers to these questions are presented graphically in Fig. 5. The abscissa of the chart is various percentages non-conforming plotted against the chance of rejecting (or accepting) welding of that particular quality for the three "lot tolerance percentage non-conforming" selected from the nomogram. It should be observed that the three curves intersect the 10% probability point, which is the consumer's risk, at tail areas which correspond to their respective p_t values. The solid curves are the plots for samples of $n = 3$. The broken curves are for $p_t = 1.0\%$ and samples of $n = 2$, 5 and 10. The family of curves for $p_t = 1.0\%$ graphically shows how larger samples very rapidly increase the assurance of rejecting subspecification quality in addition to lowering the process minimum as previously explained.

Figure 6 shows the effect on the tail area caused by shifting the process minimum for values other than those solved for in the nomogram. The chart is made independent of the specification minimum by plotting the difference between the specification and process minimum. The tail areas are solved for the values of $\sigma = 10$ to 120. This range should include almost all possible values of standard deviations encountered in spot welding aluminum alloys and thin gages of steel. In using the chart, to find the process minimum, add the value of D obtained from the plot to the specification minimum. Note that these tail areas correspond to a consumer's risk of 10% just as in the nomogram. With this chart it should be possible to predict the expected quality of a process against the existing shop specifications (assuming the process is in control). It will probably be a surprise to many process engineers to find the actual size of the predicted tail areas or "lot tolerance percentage non-conforming under their existing shop minimums.

E. Basic Formulas and Calculations Used in Designing the Nomogram and Charts (see Fig. 1)

Lot Tolerance Average $\bar{X}p$, for a given tail area p_t.

1. $\bar{X}p$ = Specification Minimum + $t_1\sigma$

From Normal Integral Tables

p_t	t_1
1.0%	2.326
0.5%	2.576
0.1%	3.090

Process Minimum (Consumer's Risk 10%).

2. Process Minimum = $\bar{X}p + t_2\sigma/\sqrt{n}$
$= \bar{X}p + 1.282\sigma/\sqrt{n}$

From Normal Integral Tables

Area P_e	t_2
10%	1.282

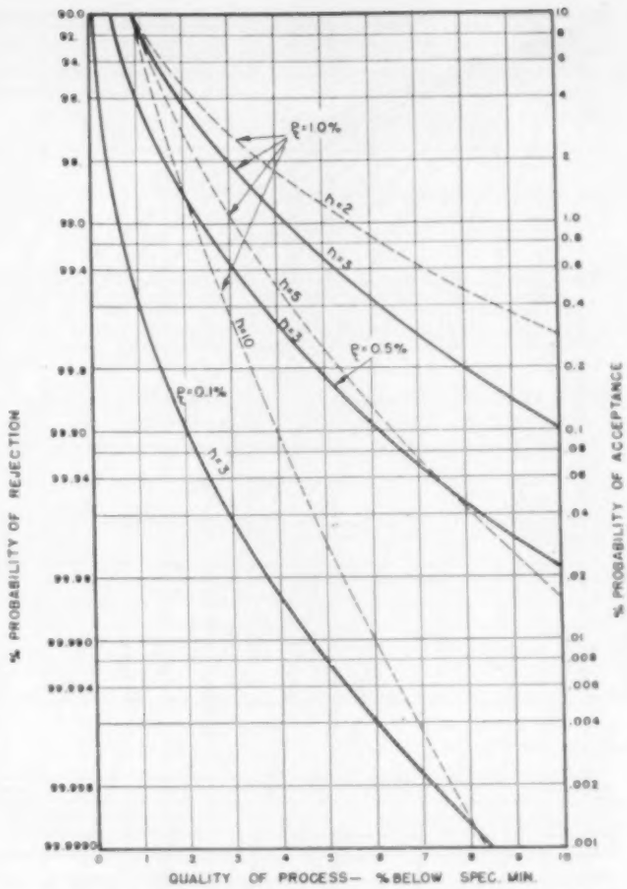

Fig. 5—Probability of Rejection (or Acceptance) vs. Quality of Process Using Process Minimum from Nomogram

Substituting Equation 1 for $\bar{X}p$ in Equation 2

Process Minimum = Spec. Min. + $t_1\sigma + 1.282\sigma/\sqrt{n}$

3. Process Mininum = Spec. Min. + $\sigma\left(t_1 + \frac{1.282}{\sqrt{n}}\right)$

Acknowledgment

The writer wishes to express his appreciation to Mr. H. Becker, Sr. Research Engineer for the design of the nomogram and to Mr. H. O. Klinke, former Chief Welding Engineer at Republic for his appreciation of the problem and cooperation throughout the study.

Appendix

General Fundamentals of Statistical Analysis

Without danger of oversimplification it may be stated that statistics deal with the analysis of data of a numerical nature. In this connection, there are two fundamental physical facts that are so obvious that they are frequently overlooked.

1. No two things are exactly alike.
2. It is impossible to make an absolutely exact measurement of a physical quantity.

The last figure of the measurement must be an estimate. If follows, therefore, that if measurements are made of a number of supposedly similar objects, or if similar measurements are made of the same object and are grouped and expressed graphically, they must neces-

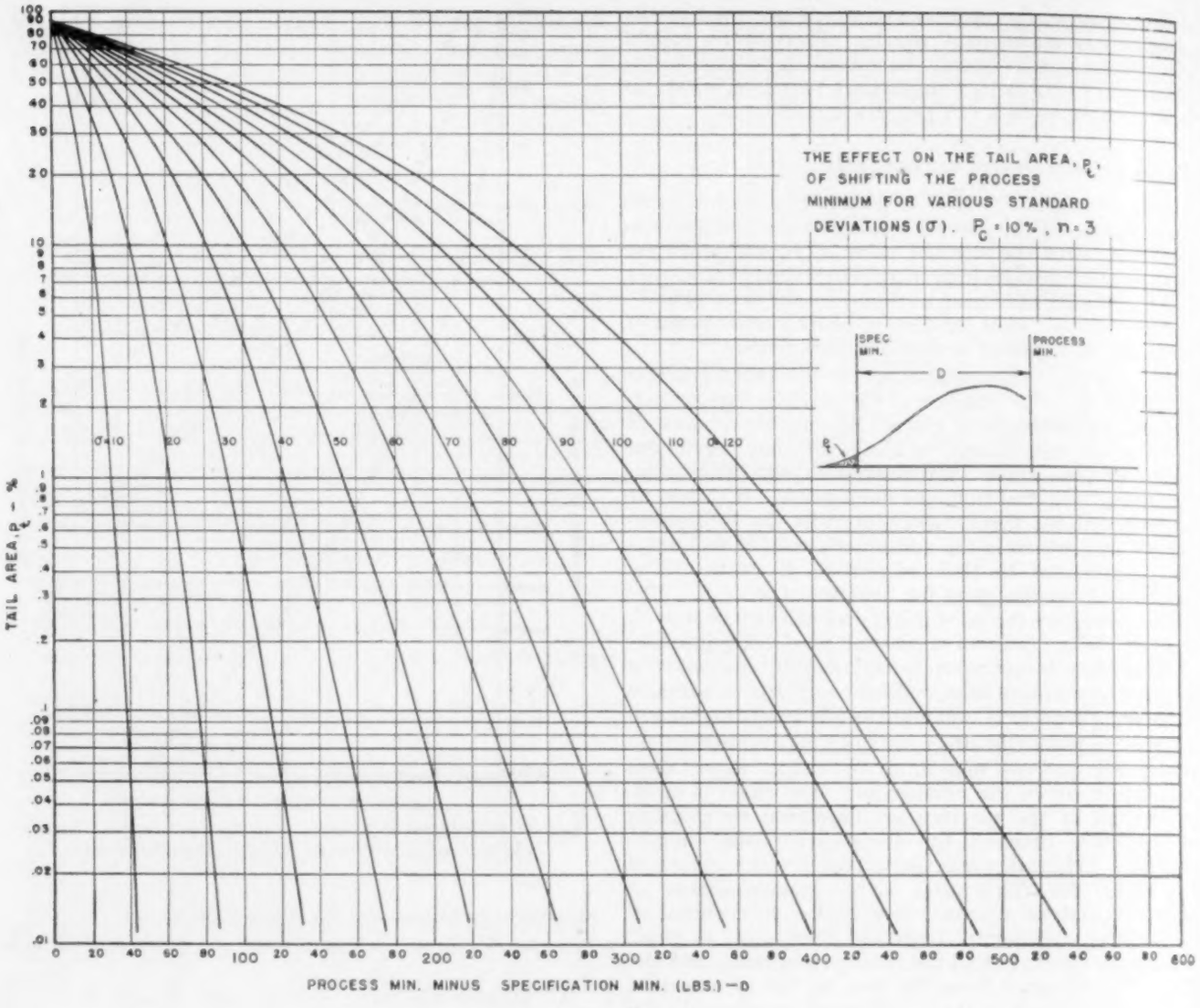

Fig. 6

sarily take the form of a frequency distribution similar to that shown by the histogram in Fig. 7 (*A*). If the number of observations are increased sufficiently and at the same time the cell width is made narrow enough, the histogram will approach the form of a smooth frequency distribution as shown in Fig. 7 (*B*).

The frequency of each cell is the number of observations in that cell. It is usually more convenient to express the frequency as per cent of the total number of observations, thus making it possible to compare the shape of various distributions in the same frequency units. Secondly, the total area under the distribution curve is 100%.

Expression of the data in the graphical form of a frequency distribution enables a clearer visualization of the various parameters used to describe the area. Using a mechanical analogy, the most important feature of the area is the center of gravity or average (the symbol is $\bar{X}$) which is simply the arithmetic mean of all the observations. The center of gravity is a function of the first moment.

$$\bar{X} = \frac{\Sigma x}{N} \qquad (1)$$

x = magnitude of a single observation
N = total number of observations

for grouped data:

$$\bar{X} = \frac{\Sigma f x'}{N} \qquad (2)$$

f = number of observations in a cell
x' = value of mid point of cell

The function of the second moment of the distribution is called the standard deviation (σ) and like $\bar{X}$ is expressed in the units of the variable. The standard deviation is the root-mean-square value of the deviations from the average of all the observations. It is best simply to consider σ as a measure of dispersion or a measure of the concentration of the data about its mean value. It is the most efficient measure of dispersion and while it is a little more trouble to compute than $\bar{X}$, for the purpose of this paper, it is of prime importance.

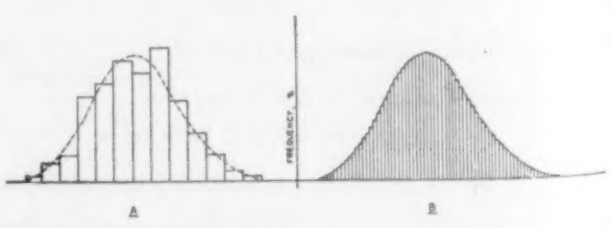

Fig. 7

Using the mechanical analogy further, σ corresponds to the radius of gyration of the distribution area.

$$\sigma = \sqrt{\frac{\Sigma(x - \bar{X})^2}{N}} \qquad (3)$$

$$\sigma = \sqrt{\frac{\Sigma x^2}{N} - \left(\frac{\Sigma x}{N}\right)^2} = \sqrt{\frac{\Sigma x^2}{N} - \bar{X}^2} \qquad (3a)$$

for grouped data:

$$\sigma = \sqrt{\frac{\Sigma f x'^2}{N} - \left(\frac{\Sigma f x'}{N}\right)^2} \qquad (4)$$

The third and fourth moments are used to determine the skewness (lack of symmetry) and kurtosis (flatness) of the distribution, respectively. The casual user of statistics will seldom have occasion to determine these values, and they are mentioned in passing as additional methods for describing the shape of the distribution.

If the abscissa is expressed in σ units with zero value at the mean, and the ordinate is expressed in per cent frequency units, we have a common set of units with which we can compare any distribution regardless of the number of observations or magnitude of the variable. In addition, we have a quantitative measure of variation. The units of variation are σ units.

Regardless of the shape of the distribution (there are no exceptions) the following expression, known as Tchebycheff's inequality, applies: the percentage of the total observations lying within the range bounded by $\bar{X} \pm t\sigma$ is greater than

$$100\left(1 - \frac{1}{t^2}\right)$$

where t is the number of σ's. More than 75% of all the observations fall between $\bar{X} \pm 2\sigma$ units and more than 89% of all the observations fall between $\bar{X} \pm 3\sigma$ units. However, this inequality is overly conservative, necessitated by the fact that we have placed no restrictions on the shape of the distribution. If we make a further provision that the distribution be smooth, unimodal (one hump), and the average approximately coincides with the most frequent value, we can use the Camp-Midel inequality which states that the per cent of the total observations lying within $\bar{X} \pm t\sigma$ is greater than

$$100\left(1 - \frac{1}{2.25t^2}\right)$$

Solution of this formula provides that:
More than 89% of the observation fall between $\bar{X} \pm 2\sigma$ units; more than 95% of the observation fall between $\bar{X} \pm 3\sigma$ units.

Though considerably better than Tchebycheff's, this inequality will also prove to be conservative, giving solutions which show less than the true percentage between limits.

There is yet another solution possible which will give a high precision of accuracy but whose solution depends on the restriction that our distribution be a *normal curve*. The normal curve is a highly idealized mathematical curve which was developed to explain laws of chance or distributions where only chance errors exist. The normal curve is smooth, unimodal and symmetric. There are further restrictions involving the third and fourth moments.

The equation for the frequency distribution of the normal curve is:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}}\, e^{-(x-\bar{X})^2/2\sigma^2}$$

It is not necessary to solve the integral of the normal curve to find the areas bound by $\bar{X} \pm t\sigma$ since they may be found by reference to normal integral tables in any book on Statistics.

95.45% of the observations falls between $\bar{X} \pm 2\sigma$ units.
99.73% of the observations falls between $\bar{X} \pm 3\sigma$ units.
100% of the observations falls between $\bar{X} \pm \infty$.

It is obvious that if we can fit the normal curve to our data our precision has been increased considerably. It should be noted that mathematically the curve is open at both ends and is asymptotic to 0% frequency. Physically we know this to be impossible and 100% of all the observations will fall well within $\pm \infty$. So far as the mathematical curve is concerned, no difficulty is here encountered since the tail areas beyond $\pm 4\sigma$'s become so small as to be negligible. While no set of data has yet been found which perfectly fits the normal integral, a large number of processes, if made under controlled conditions, can be fitted to the normal curve with a reasonable amount of accuracy. The restriction is that the process must be in statistical control before tests for normality can be applied. This point is discussed in detail in reference 1.

It has also been shown that if the data from almost any shaped distribution are divided in rational subgroup of $n \geqq 4$, and a frequency distribution made for the means of each subgroup, the resulting distribution is normal. The standard deviation will be equal to $\sigma/\sqrt{n}$ where σ is the standard deviation of individual observations. If the original distribution is normal, then the distribution of means will be normal for subgroups of $n \geqq 1$.

There are short-cut methods for determining $\bar{X}$, σ and k (skewness) that are fully described in reference 3. These three parameters, with the use of a calculating or an adding machine and table of squares and cubes, can be determined from grouped data in less than half an hour for sample sizes as large as 500 observations.

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Flash Welding 4130 Steel*

By W. W. Ackerman* and Walter Pestrak†

WHEN stresses in welded aircraft joints reached a point where the ordinary plain carbon steels failed to meet the necessary requirements, S.A.E. 4130 was developed. S.A.E. 4130 with its sister steels S.A.E. X-4130 and NE 8630 have distinguishing characteristics which make it particularly desirable as an aircraft steel. These characteristics are:

1. Excellent strength-weight ratio.
2. Outstanding weldability.
3. High tensile strength with good impact resistance.

While of outstanding weldability, however, it is only in recent years that the aircraft industry has extended flash welding to it. The advantages of the flash-welded joint over the fusion-welded joint are as follows:

1. Better physical characteristics (100% joint strength).
2. Lower weights.
3. Cheaper and faster production with less operator skill.
4. No warping as a result of welding.
5. Less brittleness at low temperatures such as are encountered at high altitudes.
6. Higher fatigue strength.

Welded assemblies made from 4130 may be used without subsequent heat treatment. However, all types of welding have effects on this steel which make heat treatment advisable wherever it is practical. One reason is to release locked-in stresses which are caused by the contraction of the metal upon cooling. Another is that just adjacent to the weld zone, a portion of the metal has been treated to just slightly below the critical temperature thus causing an annealing effect. This may result in a 10% drop in tensile strength. The third or most important is, however, that since chrome-moly is an air-hardening steel, the fast cooling of the weld results in a brittle zone next to the weld. This is particularly true in flash welding where the chilling effect of the dies is tremendous. With proper die spacing and correct machine setting, all of these can be minimized to the point where subsequent heat treatment can be dispensed with. Lockheed Aircraft Co. reports that excellent physical test results have been obtained with welded joints in which the component parts have been heat treated up to 240,000 psi., before welding, with no heat treatment after welding. Of course, if there is to be no further heat treatment after welding, the steel must be in the normalized state before welding.

Type of Applications

To the present time, the majority of applications are on tubular sections. Typical parts include an end fitting to a tube joint in which the fitting may be either forged or turned down from solid stock, or one tube to another.

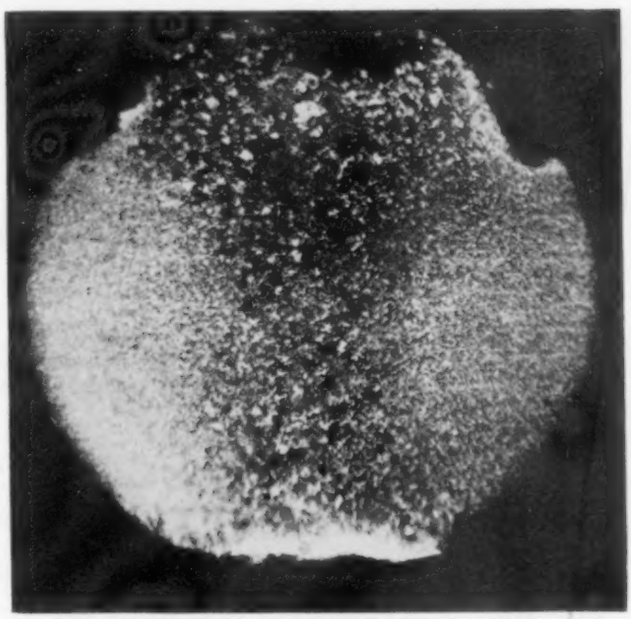

Fig. 1—Macrophotograph of X-4130 Flash Weld

The ranges welded may vary from less than 0.04 sq. in. up to over 6 sq. in.

Design Considerations

One of the greatest hindrances to flash welding is the failure of the various industries to design their parts for flash welding. The net result of this being that critical welds are obtained both from the standpoint of complete fusion and of weld brittleness along with bad alignment. The proper design of a part to be flash welded should be one in which there is sufficient clamping surface and length for die spacing with a definite machined backup. The main objection of the Aircraft Industry to the changing of the design is that since the tubular section of the forging must be lengthened this necessitates additional machining and a change of forging dies.

If the final use of parts is to be in the normalized state or at comparatively low heat treatment, all component parts may be final machined before welding and the final assembly be within customary tolerances of ±0.010 in. This is, of course, with an excellent flash welding design on the part. While these close tolerances can be held, it should be evident that they require more time for setup in the shop and require more skill from the operator. Consequently the design should not call for a tolerance which does not have to be held, for example, any part which has threaded fittings at one or both ends.

Welding Setup

Burn-off, Upset

It is logical to assume that the amount of burn-off and upset are functions of the wall thickness of the tubing and

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† Welding Engineer and Senior Welding Engineer, respectively, The Federal Machine & Welder Co., Warren, Ohio. W. W. Ackerman died in the service of his country since this article was written.

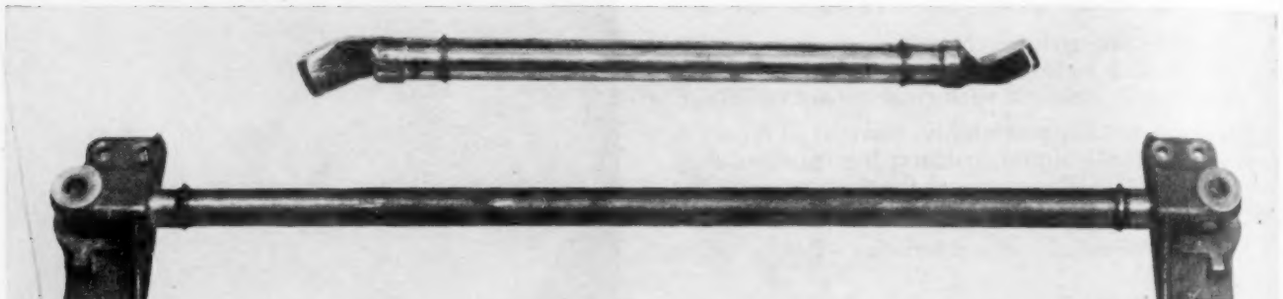

Fig. 2—(Top) Hydraulic Landing Gear Assembly; Flash Weld X-4130 Steel—Tubing to Forging. (Center) Wing Strut Assembly; Flash Weld X-4130 Steel—Tubing to Forging. (Bottom) Bomb Bay Door Bracket; Flash Weld X-4130 Steel—Tubing to Forging

should be figured on that rather than on diameter or area. The following table gives the approximate burn-off and upset for various tubing wall thicknesses.

Wall thickness	0.035	0.049	0.065	0.083	0.125	0.156	0.250
Total flash	0.190	0.290	0.345	0.395	0.430	0.485	0.532
Total upset	0.050	0.075	0.100	0.115	0.135	0.140	0.188

These values are the best available at the present time and should be satisfactory for almost all applications.

In motor-driven flash welders, the amount of upset is easily set by shimming the upset block on the cam. However, there is some question whether with hydraulic machines the cylinder should be bottomed at the end of upset or whether the resistance of the metal to further upset should be the determining factor. The great argument for bottoming the cylinder is, of course, that it gives a definite take-up. It would seem logical, however, to believe that the best and most consistent welds can be obtained if exactly the same forging pressure is applied to the weld every time. Theoretically both methods should not only give consistent welds, but also definite take-up. This is going on the assumption that the composition of the steel does not vary, that the steel is clean and that the dimensions do not vary from piece to piece and also that there is no slippage in the dies or variation in welding voltage. The uniformity of operation of the welder is also of great importance. If any of these are present, bottoming the cylinder is liable to result in faulty welds when welding a critical steel-like chrome-moly. Not bottoming the cylinder will tend to offset these to a certain extent but with a variation in upset distance. One of two compromises must be made if all conditions are not to be held constant; either the quality of the weld must be sacrificed or the amount of take-up must suffer some variation.

Upset Pressure

If the cylinder is going to be bottomed, then the upset pressure is of no influence on the weld so long as it is sufficient to insure bottoming the cylinder.

If the cylinder is not going to be bottomed, then the upset pressure is of major importance. Although upset pressure is commonly considered as a function of the cross-sectional area, it is also really a function of the compactness of the weld area. For example, take the two extreme cases. The one of a solid round section and the other of a tubular section of very large diameter with exceedingly small wall thickness. Even though both of these have equal cross-sectional area, it would be foolish to use the same upset pressure and expect similar welds.

To determine the unit upset pressure in pounds per square inch of the weld area two things must be taken into account. First, the type of steel being welded and second, the difficulty of extruding the molten metal from the weld. Unfortunately, very little is known about just what is the desirable pressure for various types of sections. This much can be stated. If excessive pressure is used, the effect upon the weld is to cause excessive brittleness and low impact strength along with probably incomplete fusion but with quite high tensile strength. There are two ways in which brittleness may be caused in the welding of 4130 and other alloy steels. The first is that due to the fast cooling of weld by the chilling action of the dies, there is in effect a quenching action on the steel not unlike actual heat treatment. Since most of these steels are air hardening, the result is brittleness in the weld zone. The second cause of brittleness is less obvious and is open to some argument. If a material is considered ductile it means that it will elongate before rupture. This elongation is obtained because of the ability of the grains in the steel to slip along each other. These grains can only slip so far until rupture is the result. If after upset in a flash weld there is excessive pressure during the cooling below the plastic temperature of the metal, the net result is that the grains have slipped as much as they are able and therefore, due to this cold working the weld is more brittle than it might have been.

According to the *R.W.M.A. Manual*, welds made with insufficient pressure are characterized by porosity, inclusion, low strength and poor impact resistance. In the

welding of chrome-moly steels, this statement is open to debate on almost all points. Taking a specific example; in welding 0.125-in. wall tubing, the upset pressure was dropped to 7000 psi. In photomacrographs taken, there were no indications of porosity or inclusions. Probably in mild steel which may contain many impurities, there would be slag inclusions with too low an upset pressure. Concerning tensile strength, in all cases, the low-pressure welds broke outside of the weld when the weld was tested in the unheat-treated state. The outstanding characteristic of the low-pressure weld was its extreme ductility as compared to that of a high-pressure weld. In every low-pressure weld there appears a white line directly through the weld.

According to metallurgists this line may be caused by a variety of things and there are various opinions about whether or not it is harmful. From work carried on up to date, the belief is that this line is not harmful if the weld is to be used in the unheated state, that is, the strength of this white line is more than that of the parent material. It is questionable whether with an exceedingly high-strength heat treatment this line will heat treat to the desired properties.

In summing up the effect of pressure, the following recommendations are made. If the weld is to be used without further heat treatment or annealing a minimum of upset pressure should be used, thus resulting in a ductile weld. However, if annealing or further heat treatment are in order, the upset pressure should be increased to about three times the minimum value since the resulting brittleness will disappear with heat treatment and with increased pressure the white line is not so predominant.

Speed of Upset

As in any flash welding, the speed of upset is very important with 4130. There are reasons to believe that the faster the upset the better the weld and perhaps the less pressure required. One reason, of course, for desiring a fast upset is to prevent oxidation of the high-temperature weld surfaces.

Die of Opening

As explained before, the chilling effect of the dies is quite large and has much influence upon the brittleness of the weld. For this reason the die opening should be kept greater for 4130 than for mild steel. Limiting factors which must be taken into account, however, are the design of the pieces being welded, the ability to hold alignment and on very light wall tubing, the deformation of the tubing under upset pressure. There is some question as to whether the die opening should be a function of the wall thickness or of the tubing diameter or of both. The following table takes into account only tubing diameter but should work all right for all of the common wall thicknesses.

Outside diam. of tube, in.	0.375	0.500	0.750	1.000	1.250	1.500	2.125
Dies at start	1.00	1.25	1.50	1.75	2.00	2.00	2.00

Flashing Time

Like burn-off and upset, the flashing time is a function of wall thickness and is quite critical in the thinner wall tubing. It is critical more from the extent of keeping a consistent flashing time after a good weld setting has been found than in an initial setting since cam design, machine operation, preparation of work and amount of upset are all influencing factors. Therefore, the values given in the following table can be varied depending upon other conditions.

Like flashing time, upset time is a function of the wall thickness and is of extreme importance for obtaining good welds. For thin-walled tubing, it has been found necessary to cut off the current before upset in order to prevent burning off the tubing or overheating the weld. In the thicker tubing the current should be kept on until the upset is completed and perhaps some annealing action might be obtained if it is left on even longer. For heavy-walled tubing, the danger lies more in cutting off

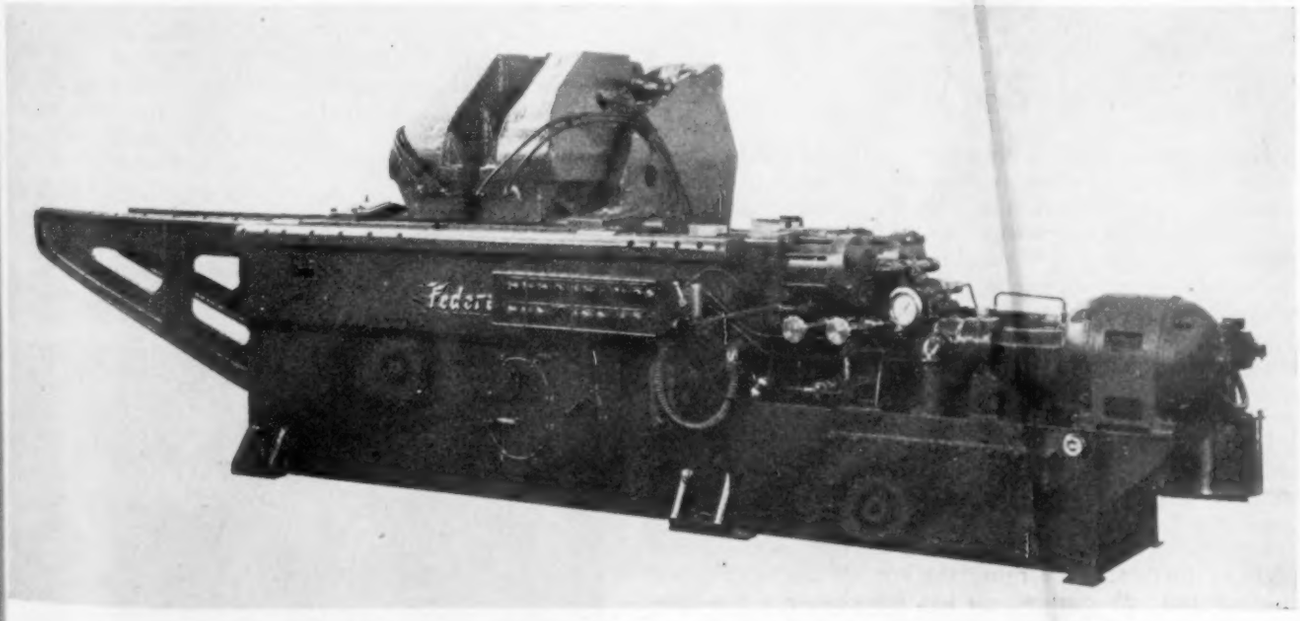

Fig. 3—A Heavy-Duty Federal Flash Welder for Welding X-4130 Chrome Moly and Other Alloys

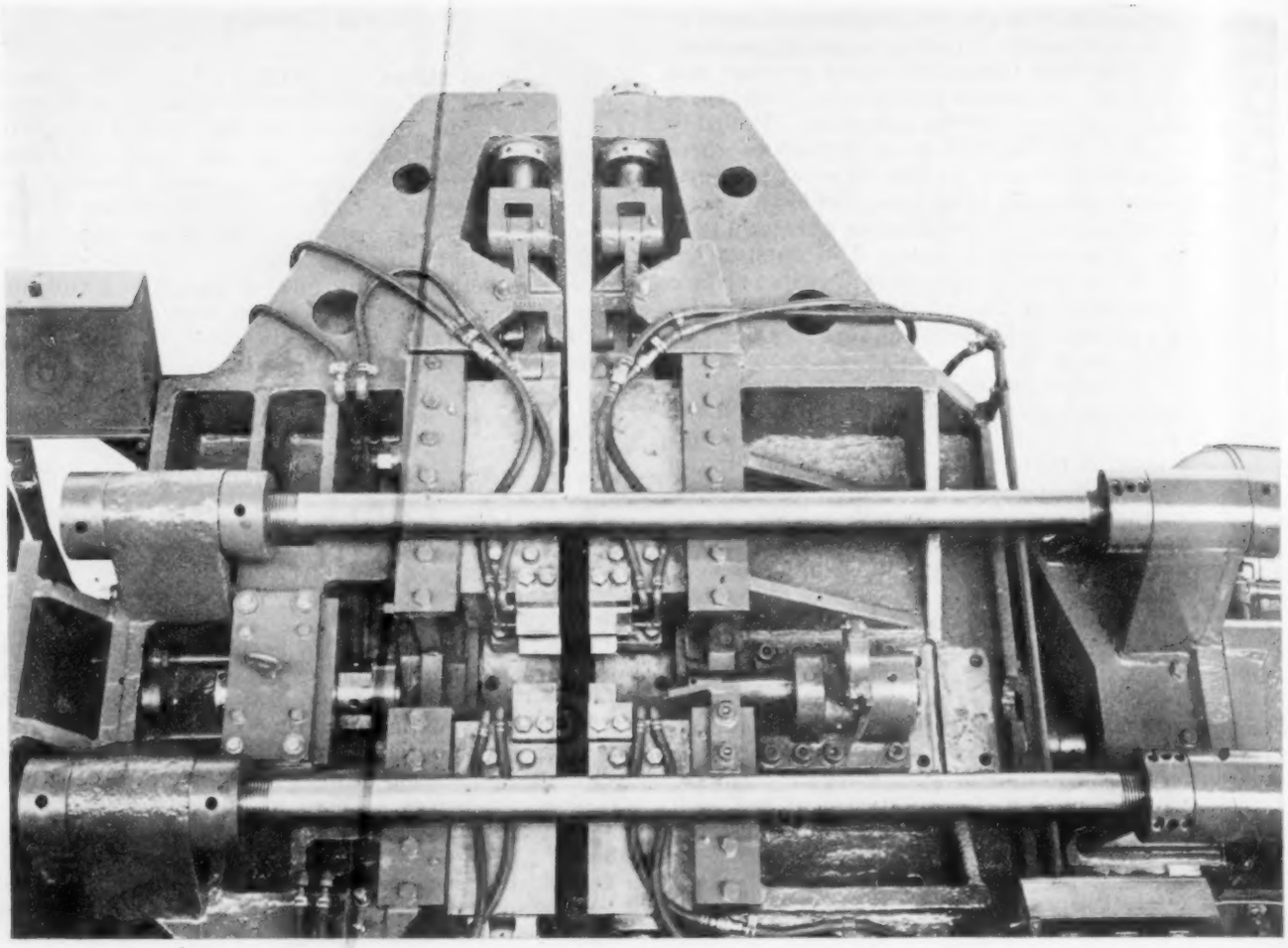

Fig. 4—Front View of a Federal Flash Welder for Welding X-4130. Showing Die and Back-up Construction

too soon than in cutting off too late. Speed of upset is of great influence upon the required current carryover.

Wall thickness	0.035	0.049	0.065	0.083	0.125	0.156	0.250
Flashing time, sec.	3.5	4.5	5.5	7	10.5	15	25
Upset time, cycles	3	5	7	9	10.5	15	30 approx.

Secondary Voltage

In welding 4130, the secondary voltage should be kept as low as possible. The customary procedure in making a setup of chrome-moly is to adjust the die opening, flash and upset distance, pressure, flashing and upset time to the desired values and then to increase the secondary voltage until no freezing is encountered. The effect of too great a secondary voltage and consequently too great a current is to cause large flash particles to be thrown out thus leaving not only large irregularities on the weld surface to be closed up, but also resulting in the case of 4130 in incomplete fusion.

If at the start very small particles are thrown out but, near the end of the flashing, large pieces of metal are emitted, the fault lies not with the secondary voltage since it is as low as it can be without causing freezing but with the cam design. Sometimes by increasing the edges of the tubing or forging, the voltage can be dropped another tap. A cam which has worked very satisfactorily for chrome-moly is one which at the beginning of flashing has a rise of 0.0005 in. per degree and at the end of flashing a rise of 0.0055 in. per degree. With this, it is desirable to bevel the edge of one tube at an angle of 60° with the center line of the weld.

Inspection of Flash Welds

At the present time we feel there is no conclusive method of nondestructively testing flash welds. While extensively tried, the X-ray has showed very little promise or has given little indication of the strength of a flash weld. In use at the present time is magnetic particle inspection or magnafluxing which has been slightly more successful in that it will reveal very bad flaws due to lack of fusion but it has not as yet been able to differentiate between good welds and those which, while containing no serious flaws, are considerably below the desired strength.

It is believed that the best available inspection method

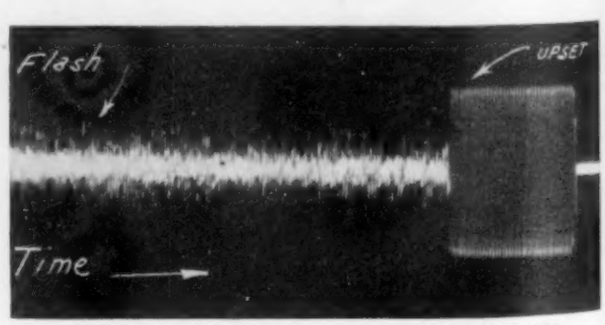

Fig. 5—Insert Oscillogram of Flash Weld in X-4130

is the close control of the equipment and the process after the machine has been properly set up. One good method of testing is as follows: On the first lot of each new part, four test coupons are furnished for each different weld. These coupons are identical to the production parts with respect to material and heat treatment, diameter and gage. Three of the coupons are tested to destruction in tension while the fourth is subjected to the test load after each 25 succeeding welds. A failure of any coupon below the test load during a production run is cause for the testing of the proceeding lot of 25 welds to determine their acceptance or rejection. If the equipment is of the proper type and properly qualified, this method will result in obtaining 100% satisfactory welds.

Joint Design for Silver Brazing Nonferrous Metals

By G. H. Bohn*

SOME suggestions are offered here, particularly regarding the design of joints that are to be made by silver brazing, since joint design is an important factor in obtaining the most satisfactory results. Only joints brazed with the oxyacetylene blowpipe are discussed—not joints made in the furnace, either by induction or by oil or gas heating. The same basic principles apply to furnace-made joints, however. In the blowpipe-brazed joint it is usually most convenient to apply the silver-brazing alloy in wire form, while in the furnace-brazed joint silver alloy washers are advantageous.

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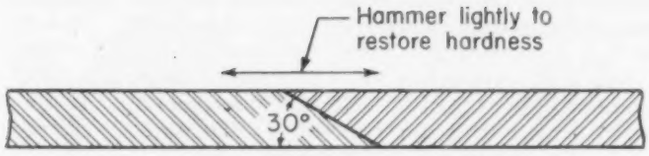
Joints in Copper

Let us consider silver-brazed joints in copper base metal first. Copper melts at 1982° F., whereas silver-brazing alloys flow at temperatures of 1300 to 1600° F., depending on the grade. The joint is, therefore, truly brazed and not welded, since the base metal does not melt. In cold-rolled copper sheet or hard copper tubing, if the edges are prepared for silver brazing by squaring them and butting them together—just as if a square butt-type weld were to be made—the silver-brazed joint will have a tensile strength of around 20,000 psi. and an elongation of about 10% (or even less) in 2 in. If, however, the edges are prepared by beveling them to an angle

Fabricating Spherical Floats for Refrigeration Units by Silver Brazing Together the Two Halves, Pressed Out of Light Sheet Copper, in a Revolving Jig



THIN SHEET

Fig. 1—Lapping the Edges at an Angle of 30° Will Materially Increase the Strength of a Silver-Brazed Joint

of 30° and lapping them, as shown in Fig. 1, a properly made silver-brazed joint will have a tensile strength of from 30,000 to 33,000 psi. and an elongation of over 40%. The strength of the joint is therefore far above the strength of the base metal and if tested to destruction, failure will occur in the base metal. It is obvious that greater strength can be expected in this type of joint, since the length of the beveled surface is twice the wall thickness. In other words, the area of bond is twice that of the square butt-type joint. Copper rods that are to be drawn into fine wire are joined in this manner.

Figure 2 shows a photomicrograph (magnified 200 times) of a cross section of a silver-brazed joint of square butt-type design in $^1/_8$-in. cold-rolled sheet copper. The upper part of the picture is silver alloy and the lower portion is copper base metal. Note the sharp black line at the juncture of the two metals. The fact that fractures in square butt-type copper joints generally occur at this point indicates an undesirable brittle structure. The use of a reducing atmosphere or of deoxidized copper will relieve this condition, but in most copper shops the joint shown in the picture is typical. (Mills usually supply copper tubing deoxidized whether it is so specified or not.)

Figure 3 shows a silver-brazed joint in copper tubing with the lap equal to two times the thickness of the wall; if this tubing is tested to destruction it should burst in the tube wall and not in the joint. Making the lap longer does not increase the bursting strength of the joint and may even decrease it because of the longer length of time the heat is on the tube. Hammering the joint lightly will restore the hardness of the copper and will also raise its yield strength decidedly, thus permitting higher test pressures to be used.

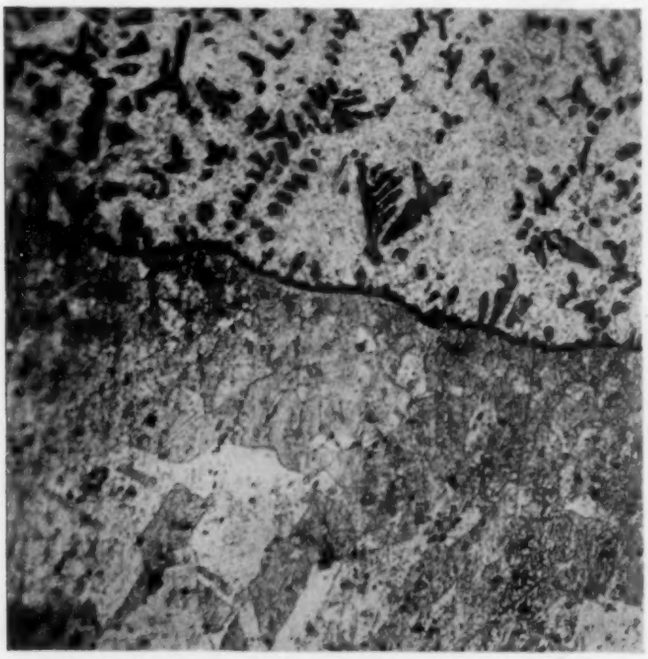


Fig. 2—Photomicrograph of a Silver-Brazed Joint. The Lower Portion Is Copper Base Metal and the Upper Portion, Silver Alloy

Thin Film

According to laboratory tests, the thinner the film of silver alloy, the higher the tensile strength, but from the practical standpoint, the joint design must provide for sufficient clearance to permit the silver alloy, drawn by capillary attraction, to spread and penetrate to all parts of the joint; otherwise full efficiency will not be attained. This is particularly important in the fabrication of containers with thick walls and in the joining of heavier copper tubing or pipe. In fabricating a pressure vessel from copper plate, for example, the joint should be prepared as shown in Fig. 4. It will be noted that while the edge

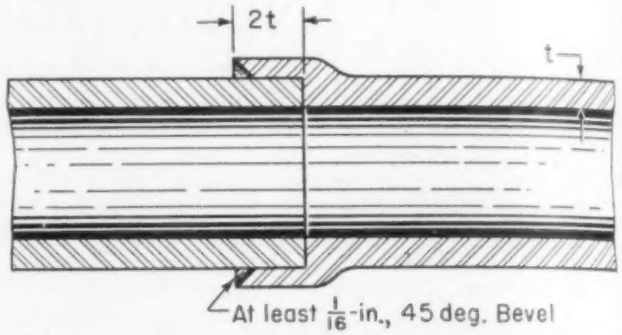
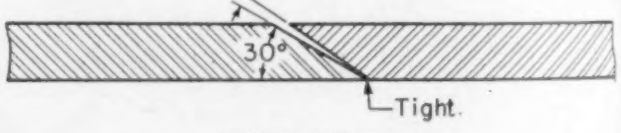


Fig. 3—In Tubing or Pipe the Length of the Lap Should Be Twice the Thickness of the Tube Wall

on one side has been beveled to a 30° angle, that on the other side was beveled to only 26 or 27°. This results in a seam that is tight at the bottom but is open three or four degrees at the top, leaving ample room for the silver alloy to enter.

Figure 5 shows a good method of preparing a lap joint in heavy-wall copper pipe. A small bevel of 45°, about $^1/_{16}$ in. deep, on the inner edge will help to start the silver alloy flowing into the joint. It will also eliminate the wasteful and unsightly overflow of expensive alloy down the outside of the pipe. An Eastern shop is using this type of joint design in fabricating piping and coils for working pressures as high as 3000 psi.



THICK SHELL

Fig. 4—In a Lap Joint in Copper Plate, Clearance of 3 or 4° Should Be Provided to Permit the Brazing Alloy to Flow Into the Joint

Brass and Similar Alloys

Silver brazing of brass, Muntz and similar alloys requires a different joint design because the melting points of these metals are so near that of silver-brazing alloys.

Metal	Melting Point, ° F.
Muntz	1661
Yellow brass	1688
Free-cutting yellow brass	1643

In order to be sure that the silver alloy will flow freely during the brazing operation, it is necessary to have the temperature some 50 to 75° F. above the melting point of the brazing alloy. Thus, with silver alloys that have melting points of 1500° F. or higher, the brazing oper-

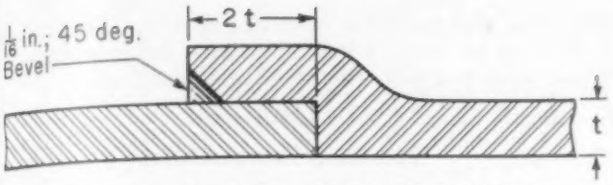


Fig. 5—Design for a Silver-Brazed Joint in Heavy-Wall Copper Tubing or Pipe

ation becomes practically a welding operation, which obviously requires a different design of joint than for copper. Even with silver alloys having melting points as low as 1370° F. (A.S.T.M. Grade 4) the design must be different. Figure 6 shows the design of a joint for brass pipe that has proved quite satisfactory. The same general idea applies for joints in brass sheet or plate. It will be noted that the length of the lap is twice the thickness of the base metal but that the lap opening is considerably greater than for copper. A bevel of about 15° usually gives the best results. Unless the larger opening is provided, difficulty will be experienced in getting the silver alloy to spread to all parts of the joint.

Everdur

Everdur 1010 is a commercial alloy consisting of copper, silicon and manganese. It has a tensile strength of about

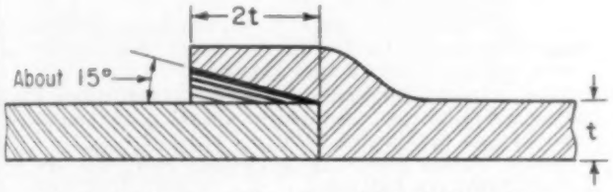


Fig. 6—Design for a Silver-Brazed Joint in Brass Pipe

60,000 psi. when welded. A silver-brazed joint in this metal does not have a brittle zone at the junction of the silver alloy and the base metal. Hence, tensile strengths of 56,000 to 60,000 psi. and ultimate shear strengths of around 28,000 psi. may be attained. As a result, silver-brazed joints in Everdur 1010 that will be under tension

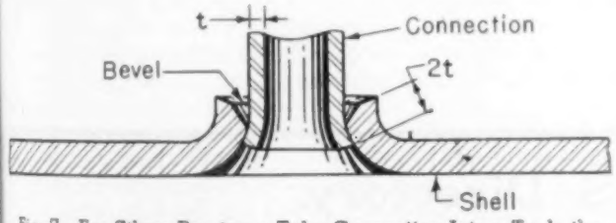


Fig. 7—For Silver Brazing a Tube Connection Into a Tank, the Shell Opening Should Be Flared so as to Obtain Twice the Tubing Wall Thickness for the Lap

in service may be of this square-butt type, but if they will be in shear, the lap design is required. This metal does not seem to require thinness in the silver alloy film.

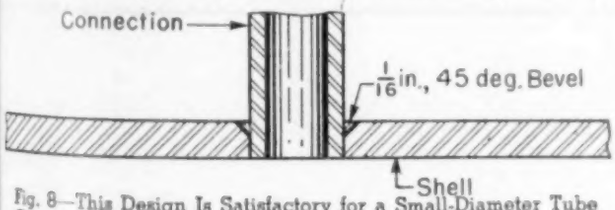


Fig. 8—This Design Is Satisfactory for a Small-Diameter Tube Connection if the Shell Thickness Is Twice That of the Tube Wall

In silver brazing a pipe or tube connection into a shell of either ferrous or nonferrous metal, it is generally advisable for a copper or brass connection—and essential for an Everdur 1010 connection—to flare the shell opening, so as to obtain $2t$ (twice the tubing wall thickness) for the lap, as shown in Fig. 7. Silver brazing this type of joint in an Everdur shell is better construction than welding, particularly if it is less than $^1/_8$ in. It can be oxyacetylene welded but silver brazing requires much less heat, greatly reducing the problem of expansion and contraction. If welded, $1^1/_4t$ is about the maximum flare for the lap. This design is not necessary for a small-diameter connection if the shell thickness is twice that of the wall. In such an instance the design shown in Fig. 8 is quite satisfactory.

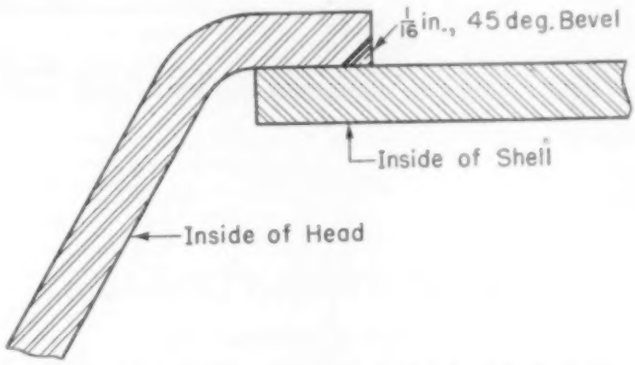


Fig. 9—Tanks with Silver-Brazed Heads Should Be So Designed That the Head Laps Over the Outside Instead of Being Inserted Inside the Shell

Tank and Container Heads

In fabricating a tank or container, whether of copper, brass, steel or other metal, in which the head is silver brazed on, the joint should be designed as shown in Fig. 9, that is, with the head lapped over on the outside of the shell. This will make fabrication much easier. If the head flange is inserted inside the shell, the outside diameter of the free end of the shell will expand during heating more than the outside diameter of the head, and trouble will be encountered from cracking during cooling. The heavier the material, the worse this condition becomes.

In silver-brazing operations, just as in welding, it is advisable whenever possible to avoid joining two pieces of unequal thickness, as shown in Fig. 10, for example. This can often be avoided by redesigning the joint, as shown in Fig. 11, so that the mass of the adjoining parts are equal. Obviously, less heat will be required to make

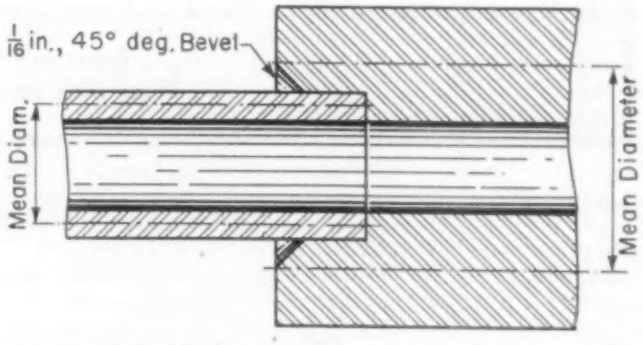


Fig. 10—If the Metal on One Side of the Joint Is Thicker than on the Other, Uneven Contraction May Give Rise to Difficulty

the joint. The difference in expansion on heating and contraction on cooling depends on the mean diameters of the adjoining parts. The difference in mean diameters in Fig. 10 is much greater than in Fig. 11. Therefore, the expansion on heating will be greater and may cause the silver alloy to crack when cooling takes place.

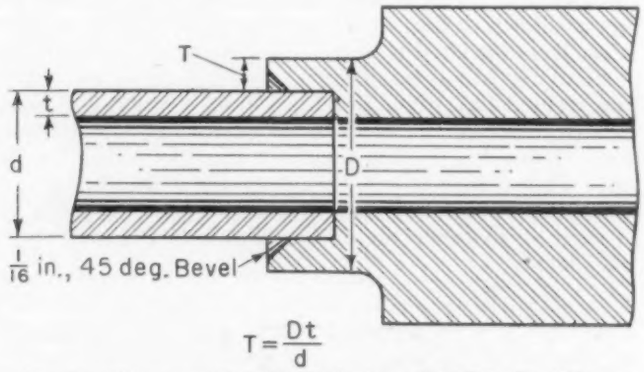


Fig. 11—Whenever Possible, Redesign a Joint Like That Shown in Fig. 10 so That the Mass on Each Side Will Be About Equal

Operating Temperatures

At elevated temperatures the strength of most silver-brazing alloys decreases, so that at 500° F. the strength will be about 50% of that at room temperature. However, fabrications of nonferrous metal whether silver brazed or not, in order to meet specifications of the A.S.M.E. Code, must be designed for lower working stresses for operating temperatures of 250° F. or above.

At sub-zero temperatures most silver-brazing alloys are not affected and the strength of the joint depends on the strength of the metal. The nonferrous metals discussed in this article actually increase in tensile and yield strengths as the temperature decreases.

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(*Continued from page 454*)

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Strength of Welded Ships*

By R. T. Young†

Introduction

A GREAT deal of discussion has taken place in recent years regarding the relative merits of riveted and welded ships. It is well known that some structural failures have occurred in the latter; some of these have been of a serious nature but by far the greater proportion have been of a very minor type. It is my intention to try to clarify some of the misconceptions which have appeared regarding this subject and also to express some opinions which are my own and in no way represent those of the American Bureau of Shipping.

Ship Stresses

Let us discuss first of all the principal stresses to which a ship is subjected while in service; these are compressive, tensile and shearing stresses. The hull of a ship is in reality an enormous box girder and when in a seaway is subjected to bending and shearing stresses just like any other girder which is carrying a load. Let us take, for example, a steel bar six feet long with a cross section three inches square and support it at either end; then apply a concentrated load at the center of the bar and keep increasing the load until failure of the bar takes place. Let us assume that the value of the load at the time the bar fractured was 15,000 lb. If we now put a small nick in one of the lower corners of a similar bar and again subject it to bending we will find that the bar will fail under considerably less load.

In the original bar with the 15,000-lb. load the fiber stress in the bar at failure would be 60,000 psi. This stress would be tensile and would be in the bottom outside fibers of the bar at the second before fracture occurred. At this time the stress in a horizontal plane through the center of the bar, which is the neutral axis, would be zero. We see then that in any structure subjected to bending the greatest bending stress occurs in the fibers of the steel which are farthest away from the neutral axis.

Returning now to a ship we can liken the hull girder to the square bar. A long and involved calculation is necessary to determine the exact location of the neutral axis of the hull girder, but in a two-deck vessel such as the Liberty ship its location will be found to be approximately at a point slightly less than one-half the depth of the vessel. This means that the points farthest away from the neutral axis, which are the most highly stressed points under load, are the bilge strakes and the upper gunwale connections which include the upper edge of the sheerstrakes and the outboard edges of the upper deck stringer plates. It is imperative, therefore, that nicks, gouges and faulty welds be eliminated at these important points. The presence of any of these, which disrupt the continuity of the stress flow, have the effect of crowding the stress lines which is the equivalent of increasing the service stresses at that point.

In the square bar the material is to all intents and purposes homogeneous. Therefore, the stresses in the bar are uniaxial. In a ship, however, the geometry and structural design of the hull complicate matters which introduce biaxial and even triaxial stresses.

Referring back to the square bar, suppose we put this in a tension testing machine and apply an axial load. As the load increases the bar elongates and the cross-sectional area thins or necks down; as long as there is no other force present to prevent this necking the stress in the bar will be uniaxial. If now we apply a force to two opposite sides of the bar and normal to its axis these forces will tend to prevent necking in one direction and a condition of biaxial stress will exist. A similar force applied to the remaining two sides with the other forces still acting will prevent necking in the second direction and produce a condition of triaxial stress.

Effect of Design on Stresses

Let us examine, then, how the structural design of the ship can produce similar multiaxial stresses in the hull girder. Assume the ship to be in a hogging condition which will produce tension in the upper deck. This force will tend to stretch the deck plates longitudinally and at the same time make them narrower and thinner. Here we have the transverse deck beams which are quite rigid members and they exert a force which tends to prevent the narrowing of the plates and introduces biaxial stresses. In a similar manner vertical members such as bulkheads, deckhouses and hatch coamings can produce triaxial stresses.

In any structure as complicated as a ship it becomes almost an impossibility to trace the lines of stress flow. Stresses in a ship are still in the unknown category but the invention of the SR-4 strain gages has enabled a number of investigators to learn more than has ever previously been found out.

So much for the tension and compressive stresses which are present in a ship in service. A third one is always present which is no less important and that is the shearing stress.

Suppose we take a laminated bar and support it at two ends. The various layers making up the bar are entirely separate from one another. We apply a load at the center subjecting the bar to bending and we find that a comparatively light load will produce considerable deflection. Now if we put three pegs through all layers and again apply a load we find that a considerably greater load is necessary to produce the same deflection. It is obvious that as the bar bends, each layer tends to slide over the other. The addition of the pegs or fasteners prevents this sliding by taking up the shearing action between the layers; obviously this puts a shearing stress in the pegs.

Comparing a ship with our laminated bar we see that the decks, tank top and bottom shell are equivalent to the layers in the laminated bar while the side shell represents the pegs. This means that the side shell takes the shearing stresses present in a ship due to hog-

* Presented at the February meeting, Portland, Maine, Section, A.W.S.
† Surveyor, American Bureau of Shipping.

ging or sagging; also the connections of the seams and butts of the side shell, whether they be riveted or welded, have to carry a heavy shearing load.

Where, in a girder of any description subjected to bending, the maximum tensile and compressive stresses, as previously pointed out, occur at the points which are farthest away from the neutral axis, the converse is true in shear where the maximum stresses occur at the neutral axis. In a ship the maximum shearing forces occur at the quarter points of the vessel, that is, at the points one-quarter of the length from the bow and a similar distance from the stern. In a riveted ship under 450 ft. in length the ordinary double row of rivets in the side shell seams with watertight spacing is sufficient to carry the shearing stresses at the quarter points. However, the American Bureau of Shipping Rules state that "seams of side shell about the neutral axis, at the quarter length, in vessels 450 ft. in length and over may be treble riveted at $4^1/_2$ diameters in lieu of double riveted at $3^3/_4$ diameters." In other words, the rivet spacing must be closed up if double riveting is to be maintained, otherwise a triple row of rivets must be substituted.

In a welded ship the A.B.S. rules assume that the welded connection is 100% efficient and therefore require no additional weld metal. It is the problem of the surveyors on the job to insure that the welding is 100% efficient. Everybody present here knows what a problem that is.

It is interesting to note that there have been few failures in welded ships at the quarter points in the vicinity of the neutral axis. When these have occurred they have usually been traced to faulty welds.

Ship Fractures

A great many armchair theorists have publicized their own pet ideas as to the reasons why welded ships crack. One of the commonest of these theories and the most erroneous is that welded ships are weaker than riveted ones because there is less steel in them. There is less steel in them due to the fact that almost all faying flanges are eliminated together with plate laps, etc. It should be stressed here that faying flanges in a transversely framed ship add nothing to the longitudinal strength.

If anything, a welded ship is stronger than its riveted counterpart for the following reason. The scantling tables of the American Bureau of Shipping were originally computed for riveting and consequently the loss of area resulting from the punching of rivet holes was compensated for. Present-day welded ships have longitudinal strength scantlings equal to those of riveted ships. We see, then, that our welded ships have scantlings sufficient to allow for rivet holes. There are, however, no rivet holes there and consequently the extra material is bound to reduce unit stress. Generally speaking, the presence of rivet holes will reduce the effective cross-sectional area by one-seventh.

In speaking of the longitudinal strength of a ship it might be advisable to explain what the criterion for this is. In 1929 the United States passed a law making the marking of a load line on the sides of all ocean-going vessels of over 250 gross tons compulsory. The American Bureau of Shipping was designated as the assigning authority. One requisite for the assignment of a load line is that the vessel should meet certain standards of structural strength. The standards of strength embodied in the U. S. Load Line Regulations were those agreed to at the International Load Line Convention of 1930 which were largely based on the practice of the Classification Societies. The longitudinal strength standard is expressed by a formula where the required section modulus is equal to the product of a factor, f, the moulded draft d and the moulded beam B. The factor f is taken from a table for the particular length of the ship involved. It can be seen, therefore, that a ship built to A.B.S. rules or those of any other recognized classification society, will automatically have the required longitudinal strength to meet the Load Line Regulations.

In calculating the section modulus of the hull girder of the standard type of dry cargo ship, only continuous longitudinal members are included; these are the entire bottom and side shell, the vertical keel and tank top plating including the margin plate and the deck plating outboard of the line of hatches. In a riveted ship it is also customary to include the top and bottom angle connections on the vertical keel, also the margin plate connecting angle and the gunwale bars.

One may ask why the aforementioned members are the only ones included when there are other ones which extend throughout the length of the vessel such as intercostal side girders in the double bottom, longitudinal deck girders, etc. To explain this we have to refer back to the days of riveting. In a riveted ship such members have their end connections to floors and bulkheads riveted. Although such connections will take a share of the load under compression, they will not act under tension. Rivets cannot and will not take tension and the designer must bear this in mind when compounding any riveted structure.

In a welded ship, however, the end connections of the intercostal members, being welded, will take a certain percentage of the tensile load. One can see, therefore, that in a welded ship these members, although not included in the section modulus calculation, do act and help to reduce the tensile stresses under service loads.

The question arises, then, why not include such members in the longitudinal strength calculation? The answer is to be found in the fact that the tensile strength of a rolled steel plate in the direction of its thickness is not so great as it is in the direction of rolling or normal to the direction of rolling. A simple experiment will prove this. Let us fillet weld a piece of plate to each side of another piece, in the same manner we would do in fitting a liner in a ship, and pull our sample in a tension testing machine. We will find that failure will occur by a splitting of the liner piece, similar to the way a plate separates when a lamination is present.

Another very sound reason for not including intercostal members is that a hidden lamination might exist in the plate to which the intercostal members are attached.

Stress Concentrators

Each and every fracture which occurs in a vessel in service must be analyzed individually to determine the cause and occasionally one occurs where the cause is uncertain. Generally speaking, in the majority of cases no one factor is responsible but the trouble may be traced to a combination of conditions.

One of the most common causes is faulty workmanship and in making this statement intentional faults are not meant. Rather what is meant is the number of small nicks and notches which are built into the structure sometimes unavoidably. Other factors are gas holes and slag inclusions in welds which cannot be detected except by some form of radiography. These latter act under stress in the same manner as cuts or nicks; that is to say they are "notch effects" which cause crowding of the stress lines. If these are present at points in the ship which are already highly stressed under service loads, failure very often occurs.

Here, then, is where the welding supervisor can perform a valuable service. Not only should he feel himself responsible to insure that gas holes and slag inclusions in the weld are kept to the barest possible minimum but he should check carefully to see that all nicks and cuts left by other trades are repaired. This does not mean that the shipfitter and burner supervisors should not also be responsible for cleaning up all notches left by them. However, the welding supervisors have a double interest because when a failure does occur in a welded ship it is the welding that is blamed. This all tends to give the welded ship a bad name and will raise a doubt in the minds of private shipping interests as to the advisability of building one.

Another contributing factor to welded ship failures is faulty design and in this category the inclusion of square corners is by far the most common and most detrimental. Occasionally some form of square corner will slip by the designer and draftsman and therefore be shown on the plan which is issued to the yard supervisory staff. The supervisors, in this case, upon finding such a thing on the working drawings should call it to the attention of the drawing room with a request that it be changed. Everybody makes mistakes, even the higher-ups, so if all of us all the way down the line would cooperate in this manner we would have gone a long way toward solving our welded ship problems.

While on the subject of design a word to the designers themselves will not be amiss. Somebody once said that you can't train stresses and no truer statement was ever made. Stresses will go where they want to and nobody can train them to do differently. Therefore, it is the designer's responsibility to put sufficient material where the stresses will be.

Quality of Steel

A third factor is the low notch impact value of mild steel at low temperature. This is another reason why "notch effects" in a ship structure must be eliminated. It is a characteristic of mild steel and therefore must be provided for in our design and construction. Investigations are at present being carried out in an effort to learn more about the behavior of mild steel at low temperature with a view toward improving these qualities.

So-called "dirty" steel is a fourth factor which must be taken into account. This term is usually applied to steel with a high sulphur or phosphorous content. It is worth pointing out here, however, that the amount of such steel which has been found to which a fracture could be directly attributed has been surprisingly small. This in spite of the tremendous quantity of steel which has been turned out during the war years.

Location of Fractures

Of all the major fractures which have occurred in service the following general types listed in the approximate order of their frequency are as follows: hatch corners, upper edge of sheerstrake, gunwale connections and outboard ends of main deck erection butts, bulwarks, and bilge strake including bilge keel.

In the case of the hatch corners the fracture usually starts right in the square cut in the upper deck plating for the hatch opening and propagates outboard. The extent of the break depends upon the conditions present at the time and the severity of the service stresses which are acting in that location. As you all know, in a few cases of this type the fracture has extended clear across the deck and down the shell resulting in complete failure.

Another type of fracture which might also be classified as the hatch corner type is that which starts in the inboard end of the upper deck erection butts and propagates outboard. This type is the result of poor welding of the butt itself. It is interesting to note here that in the earlier Liberty ships where the erection butts were machine welded, this type of failure was more prevalent. This was due to the fact that the butts were prepared with square edges for machine welding and could only be welded by machine up to within about one foot of the hatch coaming due to the machine fouling the horizontal stiffener on the coaming. The butt would be finished manually without any further edge preparation resulting in nothing but a wash weld. This is one of the reasons why the A.B.S. prohibits machine welding of upper deck erection butts.

Sheerstrake fractures have been caused by cuts or nicks left in the upper edge of the strake. Some of these nicks have been so small that had the surveyor requested their removal during construction he would have been accused of being overly fussy. This is the reason why we now request that the upper edge of the sheerstrake be ground to a smooth finish.

Another starting point of failures in the earlier ships which was the result of poor design was the small square recessed cut in the sheerstrake to accommodate the bracket of the accommodation ladder.

Fractures have also started in the main deck gunwale weld. These are usually the result of transverse shrinkage cracks in the weld metal itself. Peening of the individual passes of this weld helps to eliminate these shrinkage cracks. The riveted gunwale bar, of course, eliminates this problem entirely. A common misconception is that the gunwale bar was installed primarily to act as a crack stopper. Although it does act in this manner its principal advantage is that it eliminates welding the gunwale connection which under present construction methods is the last weld to be made on the ship and consequently has to be made under conditions of considerable restraint. It also happens that this connection is one of the most highly stressed in service.

The question has often been asked, are we going to require the fitting of a riveted gunwale bar on welded ships indefinitely? The answer is probably yes until we can take some of the uncertainty out of welding.

We have all noticed in building welded ships that there is a tendency for the bow and stern of the ship to rise off the keel blocks. What causes this? Obviously it must be due to the shrinkage or shortening of the upper deck and sheerstake. This results in a residual tension stress in these members which is the one thing we want to avoid. As previously pointed out the upper deck and sheerstrake have to take high tensile stresses when the ship is hogging. We cannot afford then to send them out with a high residual tensile stress already in them. Eliminating the welded gunwale connection by substituting a riveted bar helps to reduce these residual stresses.

They can also be reduced by the use of the following welding sequence even though the gunwale connection is welded. The work should be started amidships in the usual manner but the welding of the bottom shell, upper deck and uppermost and lowest strakes of the side shell should be completed ahead of the welding of the intermediate strakes of the side shell, somewhat like a horizontal V with its apex pointing toward amidships. It can be seen that with this sequence the last longitudinal connection to be welded and consequently the one with the highest residual stress will be a side shell seam at approximately the half depth of the ship; this will be very close to the neutral axis of the hull girder where,

as previously pointed out, the bending stresses due to service loads are a minimum.

Unfortunately the bulwark is too often considered as a secondary structural member and therefore less attention is paid to structural detail and workmanship. It has been the starting point of a considerable number of fractures. As previously stated, you can't train stresses and as long as the bulwark is rigidly connected to the hull girder by welding it must be treated as part of it. Fractures starting in the butts of bulwark plating can propagate indefinitely and under unfavorable conditions can possibly result in the loss of the ship.

The other two corners of the cross section of the hull girder, namely, the bilge strakes, have been known to be the starting points of serious failures. The trouble here is generally faulty welding in the bilge strake butts or the bilge keel butts. We all know that it is more difficult to make a sound butt weld in a rolled shape than in a plate. Therefore, as an added precaution the bilge keels should be sniped clear of the bilge strake in way of the bilge keel butts. If this is done should a bilge keel butt fail the fracture cannot extend into the shell. It is also advisable to snipe the bilge keel where it crosses a bilge strake butt; this prevents two welds from crossing each other. In welding a butt in a shape or plate if the root side of the weld is not easily accessible for back chipping the sealing or closing bead should be made first and the chipping done from the groove side. As we are all aware, insufficient back chipping is one of the major causes of faulty welds and the following of the above suggestions will help to eliminate this trouble especially in some critical points.

Fractures in medium steel may be classified in two distinct categories, namely, cleavage type fractures and shear fractures. Practically all of the failures experienced in ships have been of the cleavage type. A definition of both types might help to clear up some misunderstanding along these lines.

A shear failure is one in which the individual crystals of the metal are sheared into two distinct parts; this action usually takes place along a plane which is at an angle of approximately 45° to the base of the crystal. (The crystal may be considered as a cube.) Hence in a shear fracture the broken edges are at an approximate 45° angle to the surface of the plates; there is usually evidence of considerable ductility in the steel.

The fractures that we have experienced in this yard during construction are of the cleavage type; these are commonly referred to as brittle fractures when, strictly speaking, they are not. Brittleness is defined as a complete absence of ductility. In this type, failure occurs between the crystals of the metal, there being no destruction of the crystals themselves. The fracture is a sharp square break with the edges approximately perpendicular to the surface of the plate.

In a cleavage fracture the failure starts internally, that is, in the center of the thickness of the plate and propagates in that manner working outward to the surface of the plates. It can be seen, therefore, that the visual end of such a crack is not the actual end; the actual end can extend as much as two inches internally beyond the apparent end as seen on the surface. In repairing such a crack by welding it is therefore of the utmost importance that a hole be drilled at least *two inches* beyond the end of the crack which shows on the surface. If this is not done an internal crack will be left in the plate after all repairs are thought to be completed.

Under normal conditions of temperature and loading the shear strength of the steel will be reached before the cleavage strength and the resulting fracture will be of the shear type. Under certain other conditions, of which a lowering of the ambient temperature seems to be a highly critical one, the cleavage strength of the material is reduced. If this is reduced to such a degree that it becomes lower than the shear strength the cleavage strength will be reached first and failure will occur in that manner. Apparently the shear strength of steel is not affected by temperature nearly as much as the cleavage strength.

In making experiments in the laboratory in an effort to learn something about the fractures which have occurred in welded ships, one of the principal difficulties has been the inability to produce a fracture of the cleavage type.

However, this type of fracture has been produced in the laboratory but it is interesting to note that it occurred under conditions of biaxial stress and at a temperature of −130° F. Occasionally a fracture of this nature will occur most unexpectedly and the difficulty then is to determine just which factor or factors were present to produce it.

Some Disadvantages of the Welded Ship

A great deal has been said and written in recent years about the advantages of welding in shipbuilding but very little has been mentioned about its disadvantages of which there are a few. Probably the greatest of these from the owner's point of view is that unless some form of radiography is used to explore the welds no one can be positively sure of the quality of the finished product. Naturally enough any private company who pays out a couple of million or more dollars for a ship wants to be thoroughly satisfied that all connections are sound to insure that the vessel will not have to be laid up a number of times during the first few years of its life. It must be remembered that when a merchant ship is tied up for repairs frequently the cost of these is only a small proportion of the total expense to the owner. The biggest loss is due to the ship not carrying any cargo and therefore not bringing in any revenue.

Making repairs on welded ships may be more or less expensive than on riveted vessels depending on the nature and extent of the repairs. On a welded ship cropping a plate is a simple enough procedure but this may not always be advisable especially as a ship gets older and corrosion enters into the picture. If slight damage occurs to one end of the plate and it is approaching the limit of its corrosion margin it will probably be more advisable to renew the whole plate while the vessel is tied up rather than cropping it. In some cases it has been found more economical to renew a shell plate on a welded ship entirely rather than removing, fairing and replacing it as would have been done on a riveted ship.

It would seem therefore that the future of the extent to which welding will be used in shipbuilding depends to a large degree upon all of us and particularly upon the welding supervisors in the shipyards. It is to their interest to insure that faulty welding be eliminated to the greatest possible extent and thereby help to give the welded ship a record of trouble-free service. The classification surveyors and owners' inspectors can help a lot but they cannot always be present when a weld is made which in the last analysis is the proper time to detect poor workmanship.

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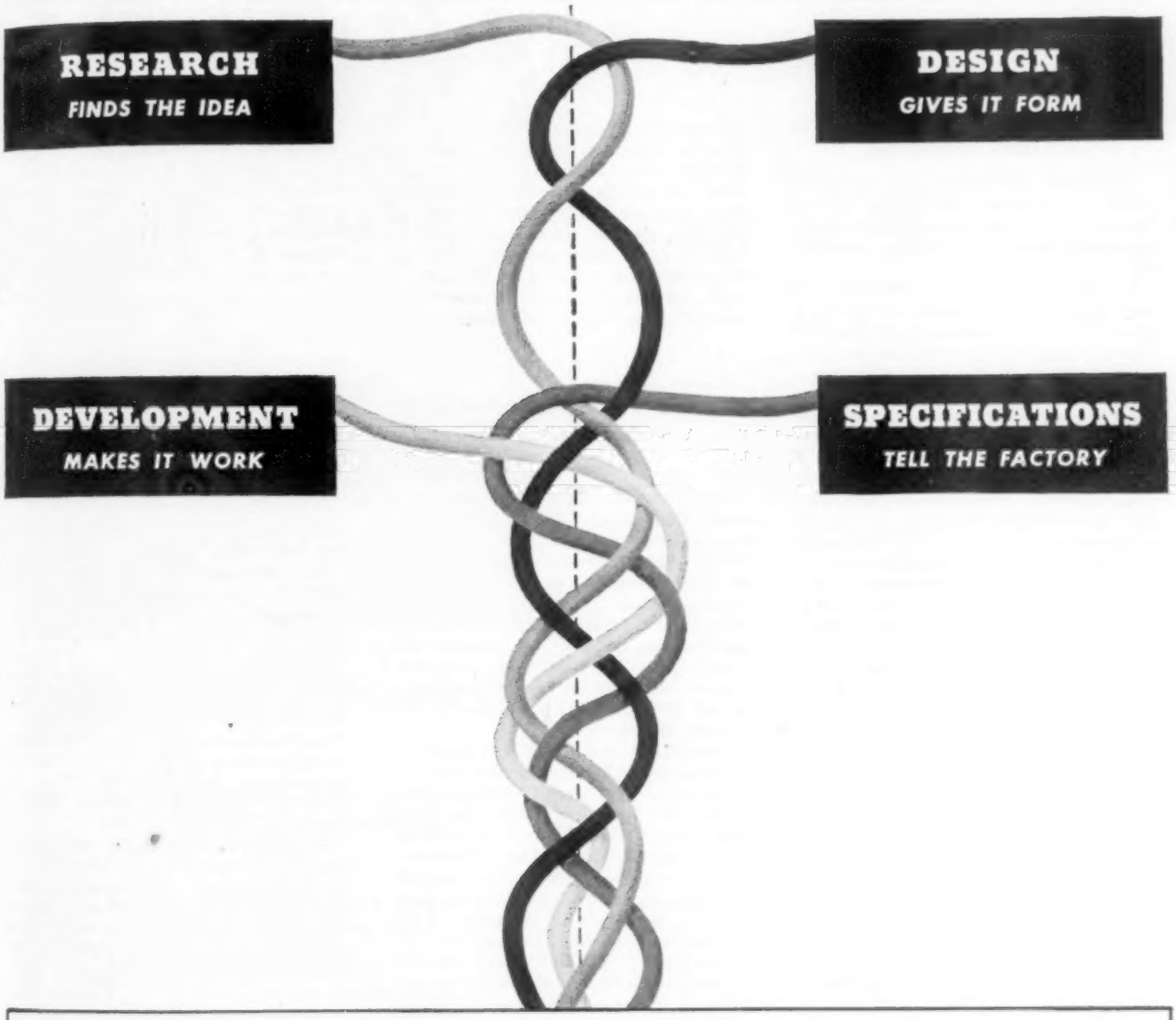

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THE AMERICAN WELDING SOCIETY

ACTIVITIES — RELATED EVENTS

SOCIETY ORGANIZES AUTOMOTIVE WELDING COMMITTEE

Among the most recent additions to the roster of technical committees of the AMERICAN WELDING SOCIETY is the newly organized Automotive Welding Committee.

Appointment of this committee was made upon recommendation of the Technical Activities Committee to the Board of Directors, after an investigation had indicated that such a committee could serve a useful purpose in bringing together into one group representatives of the automotive manufacturing industry and thereby provide a concerted effort toward the resolution of welding problems peculiar to their industry. The committee as organized will function by either delegating subcommittees to study of a particular problem or by referring such problems to the proper AMERICAN WELDING SOCIETY technical committees already functioning.

Membership on the committee includes a representative of each of the larger automobile organizations, a representative from each of the independent automotive manufacturers, and representatives of those subcontracting fabricators who supply the automotive industry with appreciable quantities of welded assemblies. This representation is indicated by the personnel which follows:

J. M. Diebold, General Motors Corp., *Chairman;* C. D. Evans, International Harvester Co., *Vice-Chairman;* S. A. Greenberg, AMERICAN WELDING SOCIETY, *Secretary;* L. W. Boelter, Ford Motor Co.; F. S. Bussell, Noblitt-Sparks Industries, Inc.; J. Calley, The Murray Corp. of America; V. H. Chisholm, Hudson Motor Car Co.; J. E. Coon, Packard Motor Car Co.; E. O. Courtemanche, Briggs Manufacturing Co.; W. E. Crawford, A. O. Smith Corp.

Also J. V. Emery, Mullins Manufacturing Corp.; C. F. Flynn, The Timken-Detroit Axle Co.; C. R. Gibbons, Wheeling Steel Corp.; J. L. Miller, Firestone Steel Products Division; R. S. Phair, Edward G. Budd Mfg. Co.; E. B. Rausch, The Studebaker Corp.; W. E. Smith, The Midland Steel Products Co.; H. R. Sparks, Chrysler Corp.; V. S. Wielosinski, Willys-Overland Motors Inc.; and C. B. Woods, Freuhauf Trailer Co.

The first meeting of the committee was heid on March 14th in Detroit, and plans were immediately formulated for study of some of the more pressing welding questions confronting the welding engineer in the automotive industry.

With the institution of the A.W.S. Automotive Welding Committee, the SOCIETY has added one further means for promulgating practices which result in the sound application of welding. This is effected through such committees which not only bring together the welding men of one industry for an exchange of ideas, but provide through an interchange of data between committees, for the dissemination of information between industries as well.

$1000 IN PRIZES FOR PAPERS ON RESISTANCE WELDING

Prize Contest Rules

In order to encourage the preparation of outstanding papers dealing with resistance-welding subjects, the Resistance Welder Manufacturers' Association has for several years conducted a prize contest, the awards for which are announced annually at the fall meeting of the AMERICAN WELDING SOCIETY. The scope of this contest has recently been increased, bringing the total amount of the awards up to $1000. The prizes are to be awarded as follows:

One prize of $500 for the best paper emanating from an industrial source, consulting engineer, government laboratory or the like, in which the major portion of the subject matter is concerned with design for resistance welding. This includes design of component parts to accomplish the maximum economy and welding quality and also details of procedure, work preparation and work handling, etc.

Two prizes of $200, each, will be awarded to the authors of two papers, not primarily concerned with design, which, in the judgment of the Board of Awards, are the greatest original contributions to the advancement and use of resistance welding. One of these two prizes shall go to the best paper emanating from a university source—that is, either an instructor, student or research fellow at a recognized university. The second of these two prizes shall be awarded for the best paper emanating from an industrial source.

A fourth prize of $100 will be awarded to the author of the best remaining paper, which may fall in any of the three groups mentioned above.

The contest is open to anyone, without restriction, from the United States, its possessions and Canada. It is also open to any member of the AMERICAN WELDING SOCIETY in any grade from any place in the world. The contest is considered as having opened September 1, 1944, and will close on midnight, July 31, 1945. Papers which are to be presented at the Annual Meeting of the AMERICAN WELDING SOCIETY in October may also be entered in this contest, in which case a draft or copy of the paper must be filed with the AMERICAN WELDING SOCIETY, 33 West 39th St., New York 18, N. Y., not later than July 31, 1945.

All papers submitted in the contest become the joint property of the R.W.M.A., and the AMERICAN WELDING SOCIETY, who will retain all rights thereto. The AMERICAN WELDING SOCIETY will appoint five judges, who will judge the relative merits of the various papers submitted and make the awards accordingly. The decision of the judges will be final.

For the author or authors to be eligible for this award, the paper shall describe clearly original work done by them or under their supervision on resistance welding in any of its aspects by any method or process. The paper shall be a full disclosure of the subject. The paper shall contain no statement which is unethical advertising or sales promotion. The paper may contain statements of fact, including the names of either individuals or organizations of any kind, commercial designations, trade names, etc. The minimum length requirement is 2500 words.

All papers must be typewritten, double spacing, written on one side only of blank white paper. Photographs, charts, graphs, etc., may either be attached directly to the copy or may be detached, in which case they should be clearly identified with figure numbers, captions, etc.

AMERICAN WELDING SOCIETY COMMITTEE ON BRAZING

The growth in brazing applications, both number and variety, in industry has pointed to the need for providing a channel through which data on these processes and their application can be cleared and correlated.

Recognizing this need, the SOCIETY has recently organized a Committee on Brazing which will undertake the preparation of recommended practices for brazing, and such standardization as is practical. The Committee will function through the correlation of data on such matters as brazing alloys and fluxes; design of brazed joints; brazing procedures and techniques; and methods of testing and inspection procedures for brazing. So

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that the Committee's work will reflect the brazing practices of all industries concerned with its use, its personnel has been selected to include at least one representative from each such industry and representatives of the manufacturers of brazing materials, as follows:

J. R. Wirt, Delco-Remy Division, General Motors Corp., *Chairman;* S. A. Greenberg, AMERICAN WELDING SOCIETY, *Secretary;* L. E. Abbott, Bell Telephone, Labs.; W. H. Cochrane, General Electric Co.; J. E. Coon, Packard Motor Car Co.; J. R. Freeman, Jr., American Brass Co.; H. T. Herbst, The Linde Air Products Co.; C. D. Hibert, Consolidated Vultee Aircraft Corp.; G. O. Hoglund, Aluminum Co. of America; Wm. H. Irwin, Carrier Corp.

Also C. E. Johnson, Scaife Co.; A. N. Kugler, Air Reduction Sales Co.; R. H. Leach, Handy & Harman; G. R. Long, G. M. C. Frigidaire Div.; A. K. Phillippi, Westinghouse Electric & Mfg. Co.; H. P. Schane, Allis-Chalmers Mfg. Co.; J. J. Vreeland, Chase Brass and Copper Co.; R. D. Wasserman (C. E. Swift, alternate), Eutectic Welding Alloys Co.; and J. C. Wilcox, The American Platinum Works.

At its first meeting, held on March 20th in New York, the Committee surveyed the general aspects of brazing and outlined the work to be accomplished. It is hoped that the work of this Committee will meet the need for authoritative data on brazing, and will serve thereby to promote the sound use of these processes.

OBITUARY

George Terry Horton

George T. Horton, President of Chicago Bridge & Iron Company, died suddenly March 19, 1945. Mr. Horton had been associated with the company, founded by his father, Horace E. Horton, since he was graduated from R.P.I. in 1893 and served as its president since his father's death in 1912.

Mr. Horton was noted as an engineer and many of the company's designs were developed by him.

Mr. Horton served as an Alumni Trustee of R.P.I. from 1925 to 1928 and had been a Life Trustee since 1929. He was an honorary member of the Western Society of Engineers and the Chicago Engineers Club and participated in the activities of the AMERICAN WELDING SOCIETY, serving as its president in 1939–40. Other engineering affiliations include: American Society of Civil Engineers, American Society for Testing Materials, Society of Naval Architects and Marine Engineers, American Petroleum Institute, and Engineers' Club of New York.

In the portrayal of Mr. Horton as a man we would like to quote the Reverend Mr. Clyde McGee of the Bethany Union Church, Chicago.

"He had a whimsical way of saying 'Whatever is, is wrong,' meaning thereby, I suspect, that in his view the last word had not yet been spoken on any aspect of life. What had been done could be improved upon. At least in that hope one was to labor and toil. He lived with face forward and with an unshuttered mind. Modesty and humility were a part of his very nature. He was a constructive thinker and possessed the gift of imagination. He had the artist's urge to give to the work of his hands an ever-added touch of thoroughness, skill and artistry. As one riding across the country catches sight of 'Horton Tanks' rising

George Terry Horton

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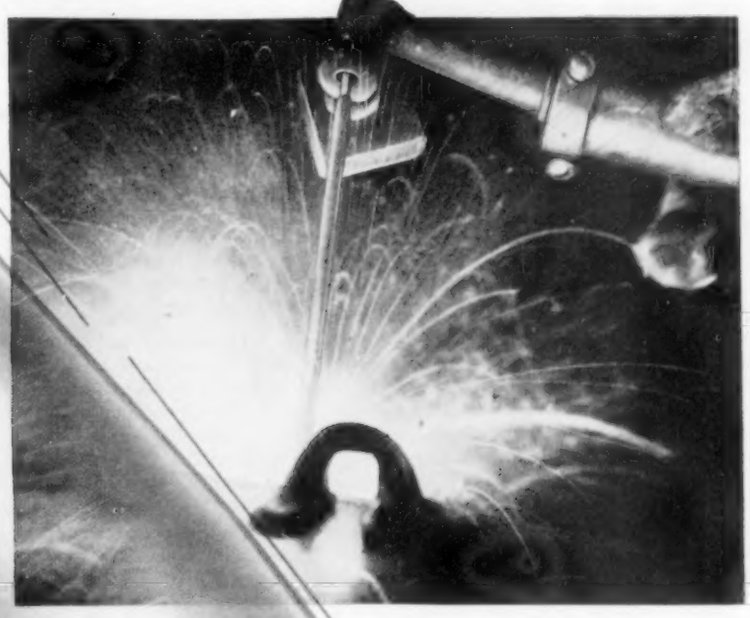

SMALL welding operations often carry big responsibilities. The lugs, for instance, by which big bombs are carried, are SMITHway welded to the bomb casing.

A potential earthquake is thus controlled by three inches of electrode . . . a minor welding operation compared with much of the work SMITHway Electrodes weld successfully; but a vital welding job, because IF that three-inch length of welding electrode isn't *right*—the consequences of failure would be terrible!

You, too, can rely on SMITHway Certified Welding Electrodes for welds that will not fail. In the A. O. Smith plants alone, more than 320,000 of these electrodes are being used every day on work that proves the value of welding as a modern production tool.

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against the skyline in town and village he sees them as expressions of the best work being done in that field. But more important he sees them as products of a Company which from its beginning has been a producer of other values, more mutuality, cooperation and good will, a feeling of common interest and common purpose running through all the organization, giving it a distinctive tone and character. In all the processes involved in the making and erection of tanks the human values were never given a secondary place with Mr. Horton. The humblest worker was made to feel his importance to the whole enterprise, his worth was given recognition and his fidelity appreciated. Mr. Horton shared his life usefully. He touched many hearts with kindness."

In the death of George Terry Horton, the AMERICAN WELDING SOCIETY and the Welding Research Council lost one of its best friends. He contributed generously and unselfishly to both organizations. Although his company is not an important user of Resistance Welding, he gave the necessary funds to establish one of the finest resistance-welding research laboratories in the country at Rensselaer Polytechnic Institute. From this laboratory have come the results which have established many of the optimum conditions for spot welding of steel and the wide application of spot welding of aluminum alloys in aircraft production. This is only one of many gifts to the advancement of welding research.

Those who came in contact with him will feel in his passing a real loss and will cherish his memory with affection.

EXECUTIVE COMMITTEE MEETING

The meeting of the Executive Committee, A.W.S., held on March 15, 1945, was called to order by President Weigel at 10:10 A.M., with the following present: C. A. Adams, O. B. J. Fraser, W. F. Hess, H. O. Hill, W. Spraragen, S. A. Greenberg and M. M. Kelly.

Approval of Change in Technical Activities Committee Personnel

With the approval of the Technical Activities Committee Chairman, the name of Mr. H. M. Priest was offered as a substitute for Mr. Wilson.

Final Report 1942 Welding Handbook Committee

The Executive Committee was enthusiastic in its praise of the accomplishments of the Handbook Committee, and in voting the acceptance of its final report the Executive Committee asked that the President convey the Society's sincere thanks to each member of the Handbook Committee, not only for his contribution of time and effort in producing so valuable a book, but also for making possible the turning over of $10,000 to the Permanent Reserve Funds of the SOCIETY, after insuring a sufficient balance in the Handbook account to enable the new Handbook Committee to commence work on the revised edition, when authorized. With the acceptance of this report, the 1942 Welding Handbook Committee was discharged with sincere appreciation.

Consideration was next given to the appointment of a Handbook Committee to undertake the preparation of the revised edition—consisting of a Chairman, four members at large, and an editor to be selected by the Committee when the personnel of the Committee, exclusive of the editor, is complete. Upon recommendation of the President, Mr. H. C. Boardman was appointed chairman of the new committee.

Discussion centered next on requirements of the office of editor and manager of publication of the *Welding Handbook*. It was generally agreed that the editing and publication management of the *Welding Handbook* is not a full-time job and the man selected as editor ought to be capable of handling other books of the order of the Handbook.

R.W.M.A. $1000 Prize Contest for Technical Papers on Resistance-Welding Subjects

Consideration was given to R.W.M.A.'s request that the A.W.S. administer this contest and appoint three Judges of Award. (EDITOR'S NOTE: Rules are published elsewhere in the JOURNAL.)

Subject to R.W.M.A.'s approval of in-

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VENTILATED HELMET

(Cat. No. 87X578) Equipped with a crown sheet for skull protection, this helmet features screened ventilators which provide cool comfort and prevent fogging of the glass. Included also are eye-protective lens, lens gasket, clear cover glass, adjustable chin rest, head gear, snap-on sweatband.

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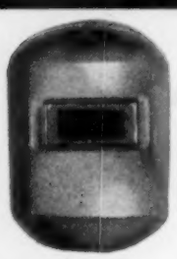

TREATED COVER GLASS

(Cat. No. 98X349) Coated on both sides with a tough, transparent, moistureproof compound this cover glass helps to maintain clear vision and is highly resistant to weld-spatter. Efficiency of coating gives this glass many times the life of an untreated glass.

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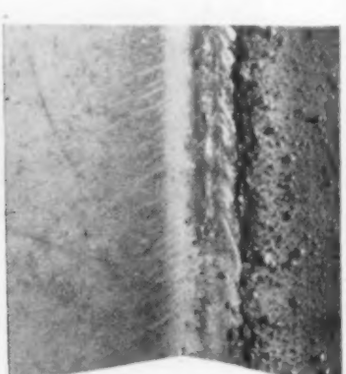
(Cat. No. 92X512) A necessary tool for both operators and inspectors, this handy fillet-weld gage provides a quick, accurate means of gaging fillets which have a straight, concave, or convex contour of the following sizes: 1/4 in., 5/16 in., 3/8 in., 7/16 in., 1/2 in. and 5/8 in.

(List Price $1.25)



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No. 1294—Weld-spatter Preventive Coating. A single coating of No. 1294 prevents adhesion of weld-spatter for either singlepass or multipass welds. Especially suitable when fabricating stainless or special alloy steels.

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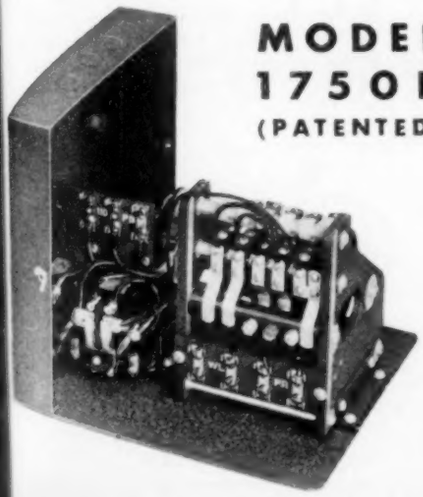
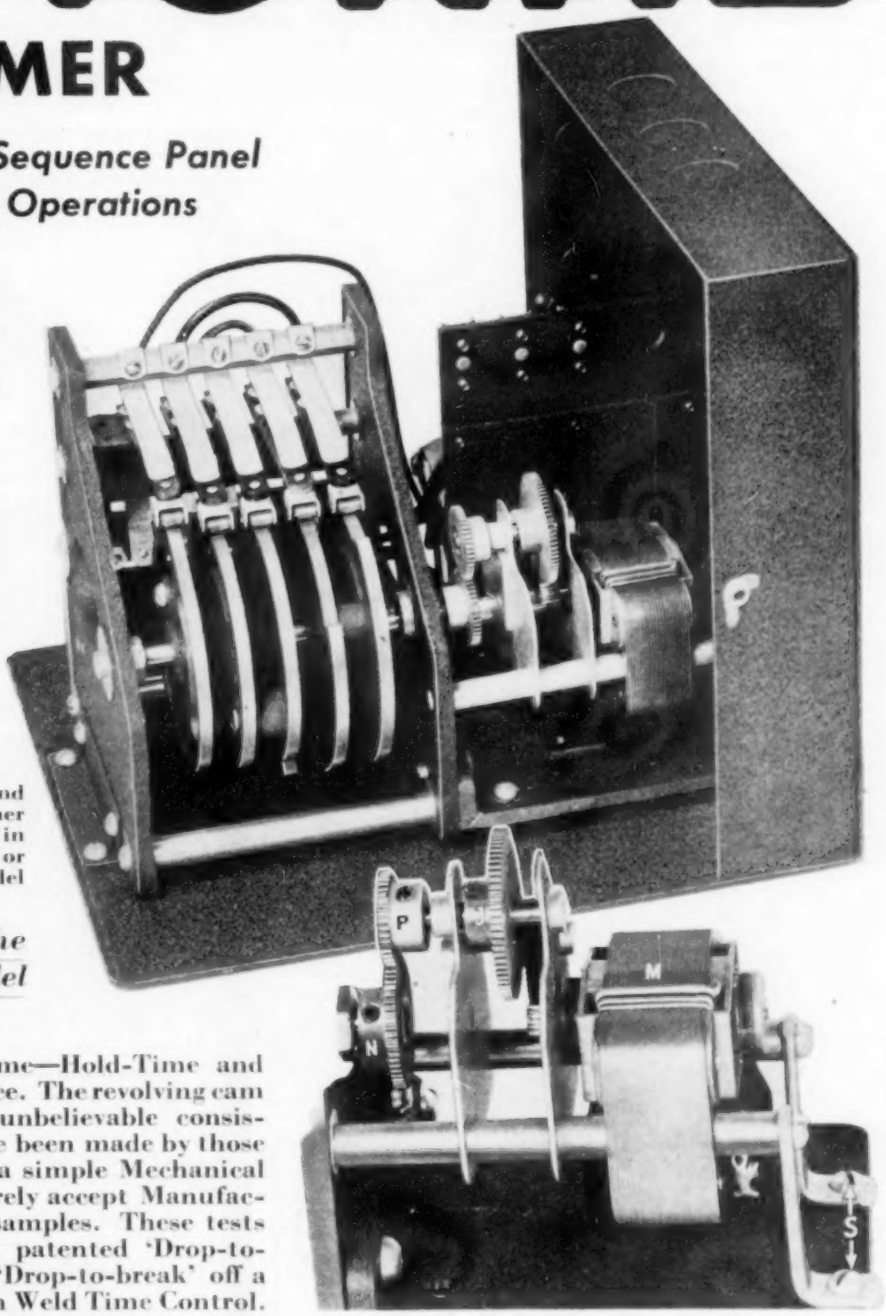
MODEL 1750P (PATENTED)





Above: Left View showing Control relays and Input Wire Connections. Right: The Timer with cover removed, reveals every function in full, accessible view. There are NO tubes, or hidden, invisible operations, with Model 1750 P.

Simplicity is the Keynote in the design of this New 1945 Model 1750P Weld-Timer

It controls Squeeze-time—Weld-time—Hold-Time and Off-interval—ALL in positive sequence. The revolving cam assembly accomplishes this with unbelievable consistency. Countless Oscillograms have been made by those in doubt, who were eager to adopt a simple Mechanical Weld-control, but unwilling to merely accept Manufacturer's statements, and Spot-weld samples. These tests proved the Accuracy of National's patented 'Drop-to-make' off one cam, followed by 'Drop-to-break' off a companion cam method of Precision Weld Time Control. You can obtain a One-cycle weld, or a 20-cycle weld, simply by positioning the fourth cam from left.

Is it any wonder that One Manufacturer is using more than 400 Type 1750P Weld-Timers on essential War Production? Dozens of plants are using upwards of 50 National Timers. It takes Performance, not Salesmanship, to get Re-orders!

Illustrated above, is the compact 1750P drive motor and change-gear train, that provides quick-change in welding rates, and motive power. The entire assembly is readily removed—just 2 screws hold it. Welding rate (RPM of cam assembly) is easy and quick to change Replace one pair of change gears, marked P and N, and you can vary the rate from 35 spots low, to over 300 spots per minute, in 24 stages. An Allen set screw holds gears on shaft. 'P' slides off shaft end to the left, and 'N' off cam shaft below to the right. Weld rate table is provided with equipment.

NATIONAL TIME & SIGNAL CORPORATION

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creasing the number of Judges of Award from three to five, it was voted that the A.W.S. accept administration of the 1945 R.W.M.A. $1000 Prize Contest for Technical Papers on Resistance-Welding Subjects, in accordance with rules contained in R.W.M.A. press release dated February 12th.

Further, it was voted that the following be named Judges of the 1945 R.W.M.A. $1000 Prize Contest: C. A. Adams, *Chairman*, P. E. Kyle, R. T. Gillette, F. R. Hensel, J. H. Cooper.

Technical Activities Committee Recommendations

Safety Recommendations.—It was reported that upon request of the Technical Activities Committee, a poll of the Committee on Safety Recommendations was taken to determine the desirability of the Society requesting A.S.A. to develop an American Standard on Safety in Electric and Gas Welding and Cutting Operations, to supersede the American War Standard bearing the same title, and the A.W.S. sponsoring a Sectional Committee for that purpose which resulted in a favorable vote of the Committee on both matters.

In connection with that sponsorship, it was pointed out that Rule 24 of Rules Governing Technical Committees provides that, in general, all specifications and recommended practices under the sponsorship of A.W.S. shall be issued at first solely by A.W.S., although eventually they may become the Standards of A.S.A.

Upon recommendation of the Technical Activities Committee, it was voted that the A.W.S. request the A.S.A to develop an American Standard on Safety in Electric and Gas Welding and Cutting Operations, to supersede the American War Standard bearing the same title; and further, that the A.S.A. be advised that A.W.S. is willing to sponsor a Sectional Committee for the purpose of preparing such a Standard, if all groups concerned so desire.

Specifications for Steel of Weldable Quality for Bridges, Buildings and Other Structural Purposes.—It was generally believed that because of the growing demand for the use of welding in structural work, it is very important that the SOCIETY foster cooperative action in bringing about the issuance of a new A.S.T.M. Specification for Weldable Steel, or a modification of the present Structural Specification, so as to make it usable for welding.

As a move in the direction indicated above, it was voted that letters be addressed to A.S.T.M. and A.I.S.I. informing them it is the belief of the Executive Board of A.W.S. that welding is being retarded in structural work because of not having a steel that is more universally weldable, and since welding will play an important part in postwar work, it is the desire of A.W.S. that consideration be given to the development of a Specification for steel of weldable quality for structural purposes, or a modification of the present Structural Specifications, so as to make them usable for welding.

Welding Requirements of New York City Building Code.—It was voted that recommendation of the Technical Activities Committee, that effort be made to effect needed change in the New York City Building Code welding requirements to bring them in accord with up-to-date A.W.S. Welding Standards, be approved, and that in transmitting this recommendation to the Public Relations Committee, suggestion be made that that Committee confer with the technical committees concerned regarding necessary changes, endeavor to obtain a hearing on the matter by the proper authorities of the City of New York, and appoint an appropriate subcommittee representing fabricators and the A.W.S. Committee on Building Codes, Bridges and Public Relations, to wait on the City of New York Building Commissioner, or other authorities having to do with the New York City Building Code.

50TH ANNIVERSARY

The Champion Rivet Co., Cleveland, Ohio, and East Chicago, Ind., manufacturers of Victor brand steel rivets and Champion welding electrodes, celebrates the 50th anniversary of the founding of the company in April of this year.

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"Outdated!" . . . he cries

LOOK, VIDKUN, OUTDATING occurs only when men take recourse to

A BETTER WAY

Such as "Lincolnweld" . . . the New Automatic Shielded Arc Welding Process:

800% Faster Output with "Lincolnweld"

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Product: Aircraft generator frames, by Jack & Heintz, Inc., Bedford, Ohio. "Lincolnweld" joins 8 rings $4\frac{3}{4}$" long by $6\frac{5}{8}$" o.d., $\frac{1}{2}$" thick, by longitudinal weld in one pass, using copper back-up bar. Rings are then broken apart. Two brackets are welded to each ring as shown in inset. Girth welds are welded in one pass. Welds pass rigid X-ray—magnaflux and torque tests. "Lincolnweld" has boosted production of these frames 800%.

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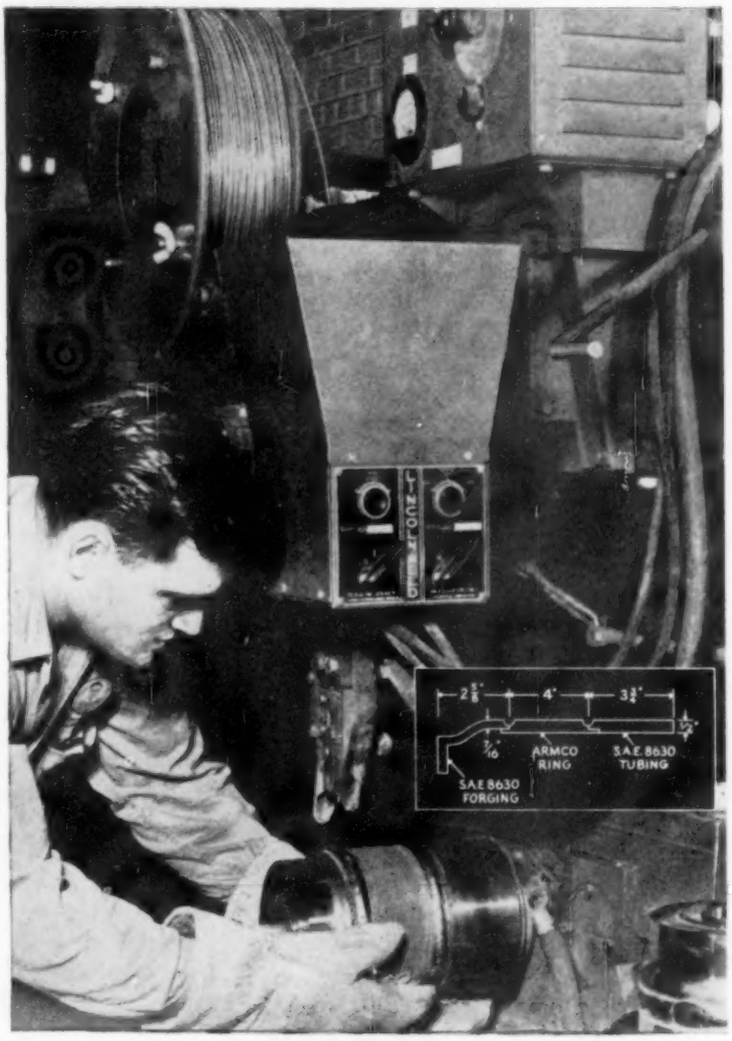
Find out how this *simplified* automatic shielded arc welding process can speed *your* output, improve *your* products and cut *your* costs. Descriptive procedure manual, Bul. 439, free on request.



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This company is reputed to be one of the largest manufacturers of large diameter rivets in the country, and is also a leading manufacturer of a complete line of mild steel welding electrodes. Their products have enjoyed universal acceptance throughout the world for both peace- and wartime fabrication.

OBITUARY

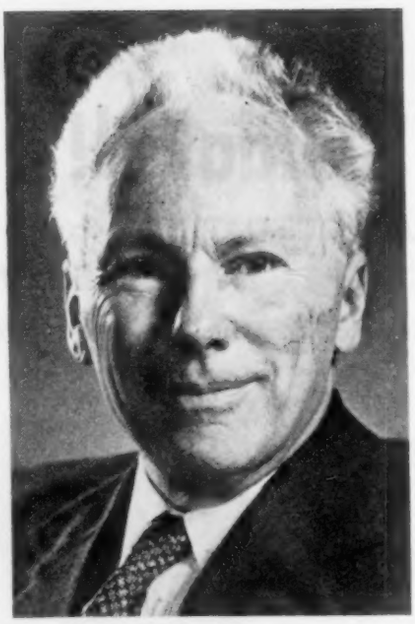
Alfred V. DeForest

Prof. Alfred V. DeForest, noted engineer and a member of the Department of Engineering at the Massachusetts Institute of Technology, died April 5th at his summer home in Marlboro, N. H. He would have been 57 years old on Saturday, April 7th.

Best known for his development of the magnaflux test, a magnetic method of discovering defects in metals, he was the founder and president of the Magnaflux Corp. Many engineering honors were conferred upon him, including the Modern Pioneers' Award in 1940 "in recognition of meritorious service to industries and to mankind in the creation of numerous new industries and countless jobs."

He was born in New York and was graduated in naval architecture from M.I.T. in 1912.

His first engineering post was in the drafting department of the New London Ship and Engine Company. A year later he joined the faculty of Princeton University as an instructor in engineering, combining his teaching with advanced studies in metallography.



From 1916 to 1918 Professor DeForest was an associate research engineer of the Union Metallic Cartridge Co., Bridgeport, Conn., and from 1918 to 1928 was research engineer of the American Chain Co.

In 1936 Professor DeForest won the Longstreth Medal of the Franklin Institute for inventions and meritorious improvements in machines and mechanical processes. The Institute of the Aeronautical Sciences awarded to him in 1938 the Sylvanus Albert Reed prize for the development of a method generally used by the aircraft industry for testing metals magnetically. He also was a recipient of the Dudley Medal of the American Society for Testing Materials.

Professor DeForest joined the faculty of M.I.T. in 1934 as an Assistant Professor of Mechanical Engineering and was promoted to a full professorship two years later. For the last few years he had been engaged in important war research. He was a widely known yachtsman, sailing his own yacht, *Meta K*.

He leaves a widow, the former Izette Taber, a daughter, Judith B., and a son, Taber.

Professor DeForest has long been identified with the welding industry. In association with the late Charles A. McCune, past-president and treasurer of the AMERICAN WELDING SOCIETY, he pioneered in the application of the magnaflux inspection and detection of defects in welded joints—a method now widely used throughout the world. At the time of his death, Professor DeForest was in charge of important investigations for the Welding Research Council relating to the effect of restraint, rate of loading and temperature on the properties of metals and welded joints.

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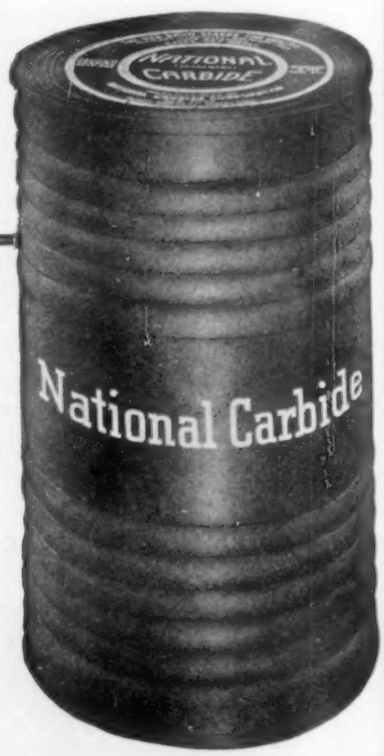

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For prompt helpful service in meeting your requirements, standard or special, contact the Tube-Turn distributor in your locality. He represents the line which is complete in more ways than one. He carries a comprehensive stock. He knows his business and is backed by the piping engineering experience of the organization that introduced and perfected seamless welding fittings.

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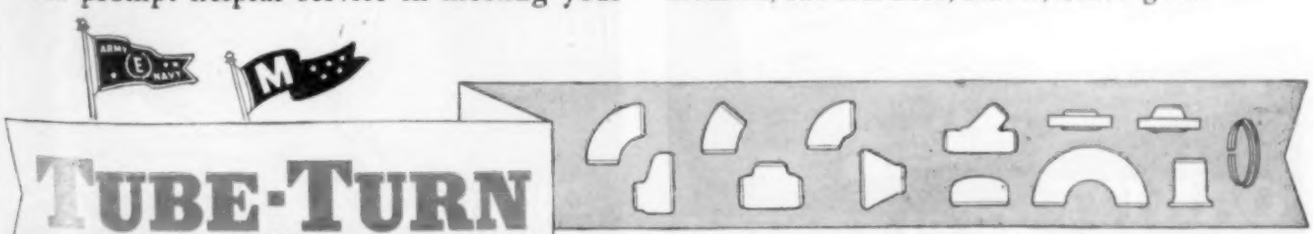

THE COMPLETE LINE OF WELDING FITTINGS AND FLANGES

LOUIS EDWARD LEVY MEDAL AWARDED TO DR. EKSERGIAN

Rupen Eksergian, chief consulting engineer for the Edward G. Budd Manufacturing Co., will receive the Levy Medal of the Franklin Institute this year, according to an announcement today by Henry Butler Allen, Secretary and Director of the Institute.

The Louis Edward Levy gold medal was founded in 1923 to be awarded to the author of a paper of especial merit published in the *Journal of the Franklin Institute*, preference being given to one describing the author's experimental and theoretical researches in a subject of fundamental importance. Dr. Eksergian's prize-winning paper was entitled, "On the Reaction of Fluids and Fluid Jets," and appeared in the May 1944 issue of the *Journal*. A discussion of rocket propulsion and jet drive for airplanes is included, together with some phases of the reaction of jets, which has been checked against experiments of a military character as yet unpublished.

Dr. Eksergian, who was born in Somerville, Mass., graduated from the Massachusetts Institute of Technology with a B.S. degree, and later received M.S. degrees from both Massachusetts Institute of Technology and Harvard University. He was also a fellow at Clark University (under A. G. Webster) from which he received his Ph.D. in Mathematical Physics.

Eksergian's contributions to present war activities were foreshadowed in the first world war when, as 1st Lieutenant, Captain and Major, in charge of Artillery Analysis, he analyzed the design of the first anti-aircraft gun of the U. S. Army. A specialist on artillery and heavy ordnance, he now is Special Consultant to Major General G. M. Barnes, Chief, Research and Development Service, Ordnance Department, United States Army, acting as adviser on technical phases of Engineering and Design. In connection with this activity he was co-founder of the Sub-Design Office of the Ordnance Department at the Franklin Institute. He is also a member of Division One, National Defense Research Committee on Ballistic Control and the Design of High Velocity Guns.

Acting as chief consulting engineer for the Edward G. Budd Manufacturing Co. since 1934, he was responsible for the technical phase of the Pioneer Zephyr, and subsequent stainless steel trains. Eksergian was previously connected with the Baldwin Locomotive Works and the E. I. du Pont de Nemours & Co. The Institute's famous Locomotive No. 60,000, driven by thousands of children as one of the action exhibits of the Museum, was proportioned by Eksergian.

His contributions to railway engineering, particularly in locomotive and car design, won him the Henderson Gold Medal of the Franklin Institute in 1937. The American Society of Mechanical Engineer awarded him the Worcester Reed Warner Medal in 1939.

The Levy Medal will be given to Dr. Eksergian at the annual Medal Day ceremonies of the Franklin Institute on April 18th.

Dr. Eksergian is a member of the Weld Stress Committee of the Welding Research Council.

SUPPORTING COMPANIES

Ford Motor Company of Canada, Limited, Windsor, Ontario, started in business in 1904, with one small drill press, a freight hoist and seventeen employees. Today there are more than 14,000 employees, all producing for war. During World War II Ford of Canada has become known as "The Largest Producers of Military Vehicles in the British Empire." More than 350,000 military vehicles of over fifty types, including tracked vehicles, have left Ford Canada plants for service on the world's battlefronts.

The L. A. Young Spring & Wire Corp., Detroit, Mich. Plants are located in Detroit, Mich. (4); Trenton, N. J.; Chicago, Ill.; Oakland and Los Angeles, Calif.; Tulsa, Okla.; Windsor and Toronto, Canada.

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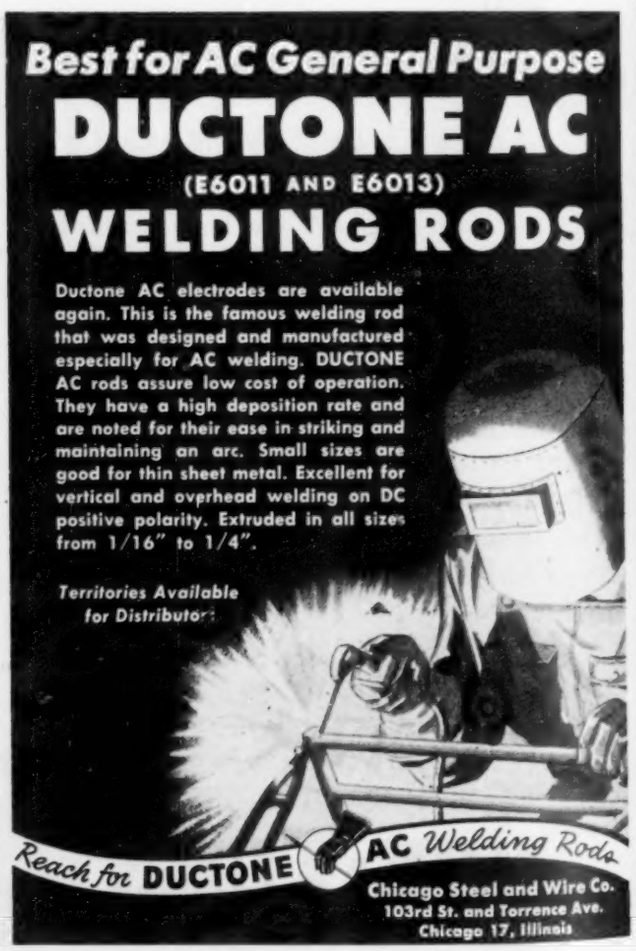
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You know that the required factor in the above problem, without which it CANNOT add up to a solution, is *increased efficiency in production.* If you apply to this challenge everything you have learned from your war experience plus *everything you can learn from the experience of others* it will still be a battle.

Federal is prepared to make available to you a wealth of information on the application of resistance welding in all of its phase to *better and faster production* (and don't say this cannot apply to your problem until you have the facts). We want to tell you about applications for resistance welding never before believed practical . . . We want to show you new ways to make profitable use of resistance welding equipment you may now have . . . to bring you up to date on the facts about resistance welding as a tool for modern production.

Federal is ready to help, if you will tell us WHAT YOU WANT TO KNOW ABOUT RESISTANCE WELDING.

Write today, stating your problem, bearing always in mind that in resistance welding, "*the name of authority is*

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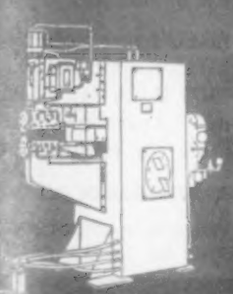

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ALUMINUM WELDERS

The limited plastic range of aluminum alloys has always made the welding of these metals an extremely critical problem, has caused many experts to claim that it cannot successfully be done. That it can, has been convincingly proved by the development of resistance welders, both spot and seam welding types, which are now producing aluminum welds of such high quality as to be acceptable for aircraft and other critical parts.

The Federal Machine and Welder Company recently delivered the largest and most modern roll-spot aluminum welder ever built, capable of welding two sheets up to 3/16" thickness . . . has others available, including spot welders capable of welding two aluminum alloy sheets up to .125" gauge at 150 spots per minute.

NEW SMALL SPOT WELDERS

Soon ready for distribution will be several improved models of small spot welders, so versatile in their usefulness and so low in cost that such users as garages, small metal fabricating shops and factory maintenance departments will find them valuable tools. Information on them is available through The Federal Machine and Welder Company.

RESISTANCE WELDING IN MAINTENANCE

Speaking of maintenance department uses, several plants where application of resistance welding would be least suspected have found small, low cost welders highly profitable for a variety of demands, from repairing or making of sheet metal safety housings to the patching of machine and electrical equipment parts.

2,000 KVA FLASH WELDERS

Among the recent special machines produced by Federal Machine and Welder Company are several 1000 KVA flash welders delivered to a foreign power as part of a complete production plant for making seven to ten foot diameter bearing rings, from hot rolled steel bar stock. Coming up are others of even greater KVA capacity. These particular rings were for tank turrets, but such welders are adaptable to handling large ring gear blanks, locomotive tires . . . many types of bars or rails up to 20 square inches cross section.

OLD TIMER . . . NEW SLOGAN

After several years total absorbtion in war work The Federal Machine and Welder Company, oldest maker of resistance welding equipment, is planning its return to active contact with peace time fields . . . has a new slogan: "In resistance welding, the name of authority is FEDERAL".

inner-springs, mechanical springs of all types except leaf springs, garment hangers and diversified wire products.

Wartime products are manifold, the most important being the manufacture of medium caliber artillery shot and shell. For achievement in this field they were awarded the Army-Navy "E" at Detroit, Mich., Trenton, N. J., and Chicago, Ill.

SUSTAINING MEMBER

The J. E. Baker Company, York, Pa., was founded in 1889 at Wrightsville, Pa. Today the company operates six plants: producing dead burned refractory dolomite at Billmeyer, Pa., and Millersville, Ohio. In addition, the company produces chemical and fluxing lime at Thomasville, Pa.; railroad ballast and crushed stone at Blue Mount, Md.; open hearth and blast furnace lime stone at Inwood, W. Va., and pulverized limestone at Edgar Plant, York, Pa. Mr. William H. Baker, son of the founder of the company, is its present president. The main office is located at 114 North George St., York, Pa.

AMPCO-TRODE LITERATURE

New literature on Ampco-Trode coated aluminum bronze weldrod has recently been issued by Ampco Metal, Inc., Milwaukee 4, Wis.

"Ampco-Trode Welding Technique," Bulletin W-2, is a 32-page booklet, describing the various methods of welding with Ampco-Trode electrodes. Sections are devoted to metallic arc, carbon arc and oxyacetylene welding. The book is well illustrated with diagrams and pictures of welding applications.

"Ampco-Trode Electrodes," Bulletin W-3, is an 8-page $8\frac{1}{2}$ x 11-in. bulletin describing in detail the five standard types of Ampco-Trode aluminum bronze weldrod. Chemical composition and physical properties are given together with information on the uses of the various types.

This printed material will be sent on request to those interested in welding.

RAIL TRAVEL

When the railroads once again solicit patronage instead of pleading with you to stay off trains, they're going to offer a whole series of wonderful new cars, comfort-designed for the ultimate in travel ease and luxury.

From the familiar commuter local to the plushiest of the transcontinental streamliners, the carriers are planning revolutionary new concepts in passenger accommodations to make your postwar travel faster, safer, more exciting and—above all—vastly more comfortable than ever before.

One of the innovations you can anticipate is a "Day-Nite" coach, which was viewed in New York recently along with other models and full-color drawings by railroad men at a special, private showing sponsored by Pullman-Standard Car Manufacturing Co., whose engineers and designers created these startling new cars. Welding plays an important part in these new luxury cars.

SELECTING AUTOMATIC ARC-WELDING EQUIPMENT

An extremely practical and informative bulletin entitled, "How to Select Equipment for Unamatic Arc Welding," is now available without charge to any companies using or planning to use automatic arc welding. This bulletin authoritatively covers the following points:

1. Direct current.
2. Alternating current.
3. "Open Arc"—using light coated wire.
4. "Protected Arc"—using light coated wire and tape.
5. "Concealed Arc"—using light coated wire with granular flux.

For a copy write Una Welding, Inc., 1615 Collamer Ave., Cleveland 10, Ohio.

USE TEMPIL°

To Measure Working Temperatures

The TEMPIL° method gives you a quick, simple and accurate means of measuring working temperatures under various conditions of heating. All three forms of TEMPIL° products melt sharply at predetermined temperatures with a mean accuracy of within 1%.

TEMPILSTIK° *for general use. Simply make a crayon-like mark with the appropriate TEMPILSTIK° on the surface to be heated. Available from 125° to 350°F in 25° steps and from 400° to 900°F in 50° steps.*

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Write today for TEMPIL° Preheating Chart, TEMPIL° scale for weld bend testing, and complete information on TEMPIL° products.

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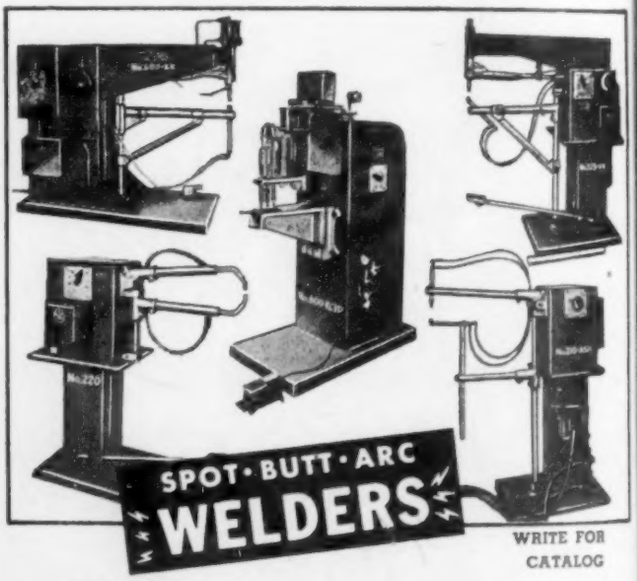

WRITE FOR CATALOG

We manufacture a complete line of resistance spot welders from ¼ to 300 KVA for all types of welding. There is an EISLER WELDER for every purpose.

TRANSFORMERS OF ALL TYPES

WE INVITE CONTRACT SPOT WELDING IN LARGE OR SMALL QUANTITIES.

CHAS. EISLER

EISLER ENGINEERING CO.

779-SO. 13th ST. Near AVON AVE. NEWARK, 3 N. J.

So Now Brownie Is Happy With A.C.

I HEARD a stricken moan and looked over at Brownie, my boss. He's our Purchasing Agent and so has a right to look unhappy—decent supplies being as scarce nowadays as prospective husbands. But I never did see him look this sunk before.

"Miss Jones," he groaned, meaning me, "I got troubles. For years our Welding Department has done a swell job with D.C. equipment and Murex electrodes. You know: FHP for downhand work, Fillex for fast fillet welding, Genex for tacking and fitup, Type M or Type 90 for high tensile steels, and so on. Now the department's installing some A.C. units, and I have to try to locate and stock a whole new group of electrodes. I feel like sticking my head in an eight-ton drop hammer and Ending It All."

"You'll do better," I said, "to stick your head in the Welding Department and ask for Joe, the foreman. And I'm going with you, to see you two don't come to blows about this."

But Joe, who's the excitable kind himself, just sort of tut-tutted poor Brownie's worries.

"Mr. Brown," Joe said, grinning, "every pound of Murex we have in stock works on both D.C. *and* A.C., including the Stainless. In fact, one of our A.C. units is already running, and going along swell on Murex."

Brownie practically collapsed on the nearest chair, he was that relieved. I felt the same way, knowing what troubles Joe's knowledge of Murex had saved me.

"And while you're here," Joe smiled, "you might take a request. Stock me some Murex Type A for vertical and overhead work on A.C., and some of their Alternex, which also does an extra-swell job on A. C. Meanwhile, forget your worries. Except for their type E6012 and E7012, practically all regular Murex electrodes work as well on alternating current as on direct."

P.S. Miss Jones back again. I found out later how Joe happened to know things about Murex my own boss didn't know. He has one of those big Murex wall charts, dividing their thirty-odd electrodes by use on mild steels, low alloys, stainless, and hard-surfacing. It also shows at a glance the AWS-ASTM grade, polarity, current, etc., of each electrode. I wrote for one for Brownie, and I think no Purchasing Agent in a plant that does welding should be without one. You just drop a line to:

METAL & THERMIT CORPORATION

120 BROADWAY, NEW YORK 5, N.Y.

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SO. SAN FRANCISCO · TORONTO

MUREX *Electrodes*

INCO DEVELOPMENT AND RESEARCH DIVISION CREATES NEW SECTIONS

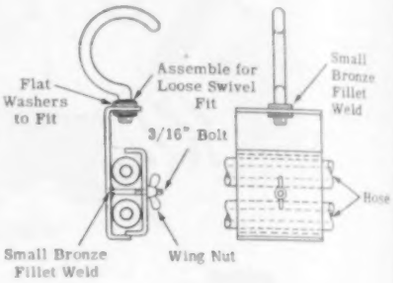
T. H. Wickenden, Manager of the Development and Research Division of The International Nickel Co., Inc., announces the formation of the following newly created sections of the Division: Industrial Chemicals Section to be headed by O. B. J. Fraser; Corrosion Engineering Section, with F. L. LaQue in charge; and Iron and Non-Ferrous Casting Section, headed by Donald J. Reese.

Mr. Fraser has directed International Nickel's investigational work at Mellon Institute of Industrial Research, Pittsburgh, Pa., on certain problems in the chemistry and technology of nickel embracing particular attention to the preparation, properties and uses of nickel compounds, especially organic derivatives and nickel catalysts. Through the Industrial Chemicals Section now established, Mr. Fraser can further expand the company's interests in this direction. He continues as Director of Technical Service of International Nickel's Mill Products, a position he has held since 1934. Mr. Fraser received his Bachelor of Science degree in Metallurgical Engineering in 1916 from Queen's University, Kingston, Ontario. He has been associated with International Nickel since 1917. He is Treasurer of the AMERICAN WELDING SOCIETY, Chairman of the Nickel Alloys Committee of the Welding Research Council, and Chairman of the Subcommittee on Refined Nickel and High Nickel Alloys, Cast and Wrought, of Committee B-2, of the American Society for Testing Materials.

Mr. Wickenden states that the function of the newly created Corrosion Engineering Section under Mr. LaQue will be to coordinate the broad interests of the company and its customers in the choice and applications of nickel-containing alloys where resistance to corrosion is required. After receiving his degree of Bachelor of Science in Chemical and Metallurgical Engineering from Queen's University in 1927, Mr. LaQue joined the Development and Research Division of International Nickel. Between 1937 and 1940 he was Assistant Director of Technical Service on Mill Products and since April of 1940 he has been engaged in development activities on all applications of both ferrous and non-ferrous nickel-containing alloys. He is chairman of the American Coordinating Committee on Corrosion created to correlate American and British corrosion data.

As head of the Iron and Non-Ferrous Casting Section, Mr. Reese will coordinate more closely International Nickel's development work on cast iron, malleable iron, cast brass and bronze. He has just recently resumed his duties with the company's Development and Research Division after having been with the Steel Division of the War Production Board at Washington for almost three years. Mr. Reese joined International Nickel in 1936. He is the author of numerous technical papers on foundry operation and is a well-known speaker throughout the industry. In 1941 he was awarded the J. H. Whiting Gold Medal of the American Foundrymen's Association for outstanding contributions to the foundry industry and the Association through his work in the improvement of cupola melting methods. He was graduated from the University of Michigan in 1925 with a degree of Bachelor of Science in Chemical Engineering. Mr. Reese is past chairman of the Chicago and the Metropolitan Chapters of the American Foundrymen's Association.

SIMPLE HOSE SUPPORT*



When desirable to suspend hose from above to protect it from damage and also for working convenience, this hose support is easily made. Use several on long hose line.

* Reprinted from Welding "Sparks," Monthly Publication of the St. Louis Section of the American Welding Society, Vol. 1, No. 1, March, 1945.

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BETTER WELDING
at
LOWER COST

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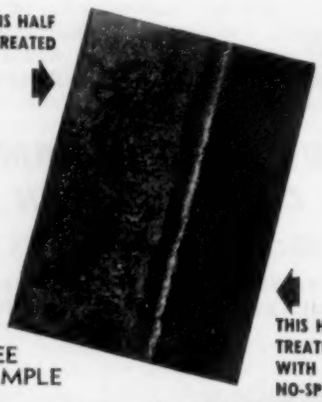

NO-SPAT
The Welding Fluid That Is Non-Toxic

FREE SAMPLE

THIS HALF TREATED WITH NO-SPAT

NO-SPAT prevents welding spatter from adhering to metal surfaces — protects metal against rust — saves time and labor costs. Especially valuable in keeping welding jigs clean. Unbiased scientific tests show NO-SPAT maintains maximum welding strength — reduces fumes 30 percent — does not produce carbon monoxide. Extremely inexpensive. No mixing required. No time wasted. Apply and start welding at once. Write for FREE SAMPLE and detailed engineering test Bulletin.

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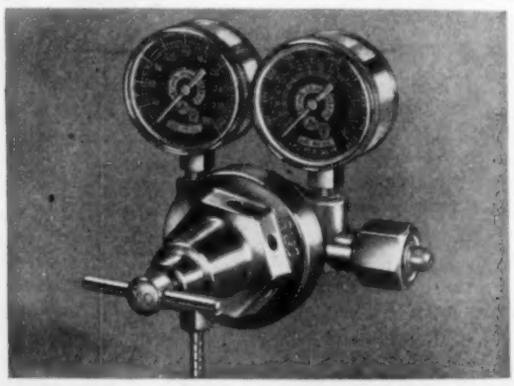

BRASS MAKES BULLETS

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Conserve your equipment.

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Pioneers and Manufacturers of Precision Equipment for Using and Controlling High Pressure Gases

WELDING CLAD STEEL is no harder than steel welding if you follow a few simple rules!

In all kinds of welding, proper preparation of the weld is more than half the battle. This is especially true in the case of welding clad steels. Here are a few tips on welding Nickel or Nickel-alloy clad steel.

WELDING THE STEEL SIDE

A butt joint should be used whenever the nature of the work permits. An exception occurs in the field erection of large storage tanks, where lap joints may be required. The most common (and preferred) procedure in arc-welding butt joints is to weld the steel side first and then the clad side.

PREPARATION OF THE STEEL SIDE

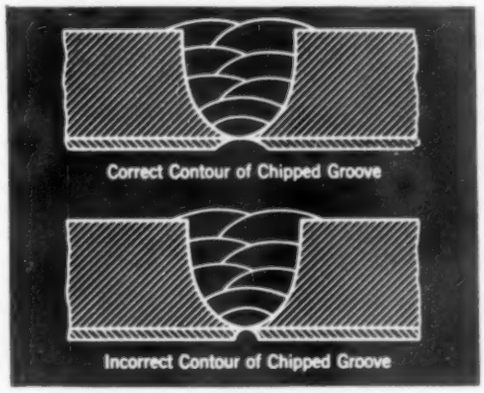
One error frequently encountered in welding clad steel is the grooving of the plate edges to leave a steel land greater than 1-16". This is accepted steel practice, but in the case of *clad* steels too thick a land will make it impossible to secure proper penetration of the steel on the first pass. For proper penetration never leave a steel lip thicker than 1-16" above the cladding metal. If this precaution is followed, it will not be necessary to cut a deep groove in the clad side in order to reach sound weld metal. By avoiding such a deep groove, you reduce the chance for iron pick-up and also make it easier to manipulate the electrode.

For the steel welding, any flux-coated electrode conforming to A.W.S. E 6010-11-12-13 grades may be used.

WELDING THE CLAD SIDE

After the steel side has been welded, the clad side of the butt joint should be chipped out to clean, sound steel weld metal and welded with suitable Nickel or Nickel-alloy electrodes.

PREPARATION OF THE CLAD SIDE



The choice of electrodes will be governed by the type of cladding. For example, on 5/8" 10% cladding, the following electrodes and amperages are recommended:

for NICKEL-CLAD STEEL—Use "131" Nickel Rod
First pass; 1/8" diameter rod – 125-130 amps.
Second pass: 5/32" diameter rod – 160-165 amps.

for "L" NICKEL-CLAD STEEL—Use "136" "L" Nickel Rod
First pass: 1/8" diameter rod – 120 amps.
Second pass: 5/32" diameter rod – 155-160 amps.

for MONEL-CLAD STEEL—Use "130X" Monel Rod
First pass: 1/8" diameter rod – 90 amps.
Second pass: 1/8" diameter rod – 95 amps.

for INCONEL-CLAD STEEL—Use "132" Inconel Rod
First pass: 1/8" diameter rod – 80 amps.
Second pass: 1/8" diameter rod – 90 amps.

In welding any type of clad steel, it is good practice to chip out half of the first pass made on the clad side. This will reduce iron dilution in succeeding beads.

The over-all requirement in building clad steel equipment is to provide a continuous surface of the cladding metal. This is readily accomplished between plates in butt and lap joints by the welded seam itself. However, at manholes, flanges, gasket surfaces, etc., a sheet covering or layer of weld metal is necessary. Overlaying is easily done by arc welding with the appropriate electrode.

Bulletin T-4, *"Methods for the Fabrication of Clad Steel Plate,"* contains general precautions to be observed in handling clad plate, sketches of methods for providing continuity of the cladding surface, recommended welding procedures, and other information helpful to welders. SEND FOR YOUR COPY.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

INCO
"130X" MONEL
"131" NICKEL
"136" "L" NICKEL
"132" INCONEL
ELECTRODES

BRAZING NEWS

A "Low Temperature Brazing News" bulletin, No. 31, has been issued by Handy & Harman, 82 Fulton St., New York 7, N. Y. A copy of this pamphlet will be mailed to anyone upon request.

PROPOSED AMERICAN WAR STANDARDS FOR RESISTANCE WELDING, C52.3, C52.4, C52.5

The War Committee on Resistance Welding has now completed its consideration of three proposed American War Standards:

C52.3 Straight and Offset Resistance Welding Electrodes and Electrode Holders.
C52.4 Controls for Resistance Welding Machines.
C52.5 Specification for Resistance Welding Machines.

MANNING PROMOTION

A new partner, Henry S. Lewis of Union, N. J., has been added to the firm of Manning Welding & Engineering Co., Inc., of 30 Ogden St., Newark, N. J. While enlarging their present scope, Manning Welding will also establish a new division under the name of Manning & Lewis and will design, manufacture and market to the trade a complete line of heat exchanges. Mr. Lewis had had over 18 years' experience in this field and is an authority in all its diversified branches.

SALVAGING CAST-IRON GAS VALVE*

This story has to do with the successful salvaging of a 24-in. diameter cast-iron gas valve by a large industrial gas company through the use of heavy-coated aluminum bronze electrodes. The gas valve is used on a carbureted water gas machine which necessitates the valve's opening and closing every 3 min. The constant operation subjects the seats of the valve to a tremendous amount of abrasive wear and erosive action, making possible a normal operating life of only 4 months. The valves have a weight of 770 lb. and in this particular instance have two seats, both of which were so badly worn and eroded that the valve was no longer serviceable.

The original price of the valve casting, including finish machining, was $130.39. The total cost of reclaiming the valve by welding, including the necessary machining operations, was $66.13.

On this application, the usual recommendations for the use of coated aluminum bronze electrode on cast iron were followed. Normal recommendations for overlaying cast iron are to use a relatively low current with a rapid weaving motion which tends to distribute the heat and prevent deep penetration. As no penetration is desirable, the electrode is directed back so that the arc plays on the deposited aluminum bronze and, in effect, the heat of the arc is passed through this molten deposited metal to the base metal. The surface of the cast iron was prepared by thorough cleaning, which included the removing of all grease, rust and foreign deposit on the cast iron. The valve was further prepared for welding by undercutting each 24-in. seat $^1/_8$ in. deep to insure the removing of all worn and eroded base metal. This undercutting also provided depth so as to have an all-weld metal deposit when the valve was finish machined for service.

Before welding, a large gas torch was used to preheat the entire valve to 400° F., which temperature was maintained during the time of welding, except for slight reduction in temperature which took place during the removal of slag from each deposited layer.

$^3/_{16}$-in. diameter electrode was used in depositing the overlay on the faces of the 1-in. wide valve seats. A down-hand position was maintained, using a regular back-step procedure to minimize the formation of stress in the cast iron. A weaving motion was followed across the 1-in. face, and deposited for a distance of about 6-in. measured along the circumference. A new deposit was then started directly op-

* Reprinted from Welding "Sparks," Monthly Publication of the St. Louis Section of the American Welding Society, Vol. 1, No. 1, March, 1945.

KRE - CO ALUMINUM BRAZING
ELIMINATES WELDING PROBLEMS

KRE-CO ALUMINUM BRAZING PROCESS makes brazing possible at a temperature safely below the melting point of the parent metal. It Speeds production—Reduces finishing costs—Cuts rejections to a minimum—Lowers gas consumption—Halves new operator training time. Makes a perfect bond. The process includes the use of KRE-CO ALUMINUM BRAZING FLUX and a standard 5% Silicon Rod. Send for Bulletin M 4.

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DIVISION OF
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Time Counts –
Gas cut and Weld with
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FOR VICTORY BUY UNITED STATES DEFENSE BONDS STAMPS
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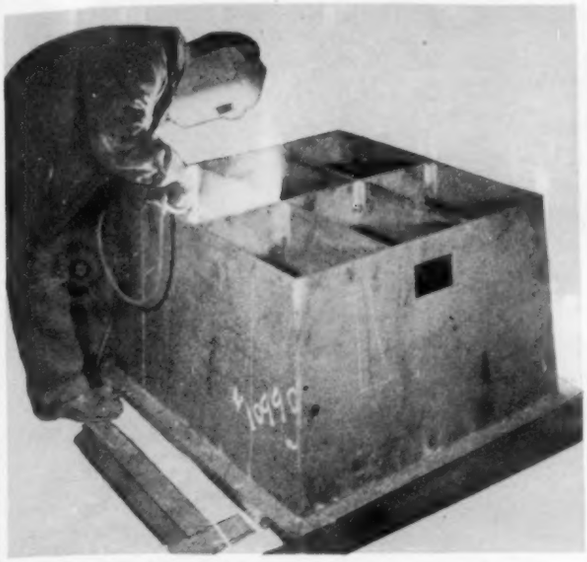
Buy "Proven Fluxes" with Years of Guaranteed Satisfaction behind them
The Trade-Name is "ANTI-BORAX"

Ask for Them *Unequalled for Quality*

A Flux for every metal: Cast Iron Welding Flux No. 1; Brazing Flux No. 2; Braz-Cast Flux No. 4 for bronze-welding cast iron; "ABC" Aluminum Flux No. 8 for sheet Aluminum and all alloys of Aluminum; Stainless Steel Flux No. 9; Silver Solder Brazing Flux No. 10; No. 16 Silver Solder Paste Flux.

ANTI-BORAX COMPOUND COMPANY
Fort Wayne, Indiana

with Airco Metal-working Methods



Arc Welding is the widely-used modern method of joining metal parts into strong, light, "one-piece" units. Teamed with machine gas cutting, this modern process provides unusually fast, economical fabrication for all types of metal products.

Braze Welding is a low-cost means of repairing cracked or fractured industrial machines and other equipment made of cast or malleable iron. It also saves time and money in building up worn surfaces such as gear teeth, valve discs and seats, pistons and similar parts.

Hand Cutting is another oxyacetylene process that enjoys wide usage throughout industry. It saves vital time on many jobs — trimming and beveling of pipe and plate; squaring; dismantling; and many other production, maintenance and salvage operations.

Flame Cleaning and Dehydrating prolongs paint life on metal structures and equipment by providing a warm clean surface that makes paint coats hold better, last longer. It quickly loosens scale and rust, permitting their easy removal. It is equally effective for preparing unpainted metal surfaces and for removing old paint and rust.

OTHER TIME-SAVING AIRCO PROCESSES

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9. Flame Nicking
10. Hard Facing
11. Pipe Welding; Gas or Arc
12. Flame Descaling

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posite on the face of the valve so as to distribute the heat and minimize stress concentration. The entire side of one face was first completed using this technique, and the valve was then turned over and the other face overlayed in exactly the same manner. The first layer on each face was deposited at 165 amp. and 30 volts, this being enough heat to make the metal flow freely without getting the penetration, and consequent objectionable amounts of iron pickup. All additional layers were deposited at 225 amp. and 31 volts. Three layers were required on each face to insure a deposit of $^1/_4$-in. depth. This depth was necessary to make sure the weld deposit would clean up when finish machined and leave approximately $^1/_8$ in. of overlay. After the aluminum bronze had been deposited so as to make it possible to obtain the desired depth of overlay, the valve was mounted on a welding positioner so that it could be rotated while in a vertical position, enabling the operator to deposit weld metal on the inside diameter so as to even out some of the spots where the horizontally deposited weld metal did not roll out far enough to be flush with the edge of the face.

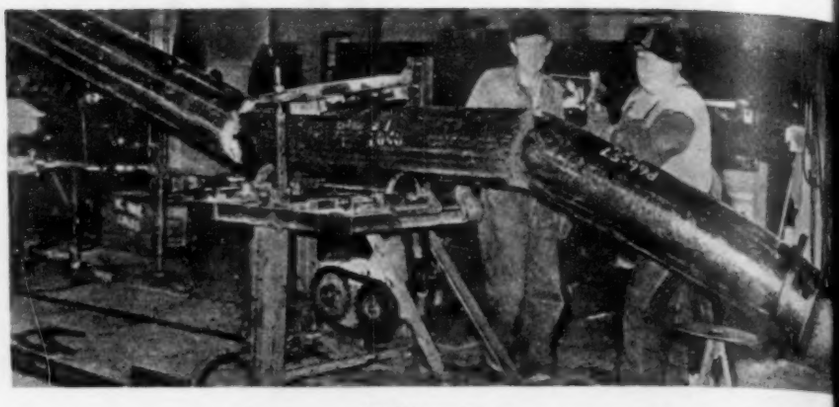
At the present writing, it is not possible to give complete information as to the wear resistance. However, after two months of service, the valve was examined and found to be in excellent condition, with very little evidence of wear. The results of this inspection and knowledge of the service characteristics of aluminum bronze indicates a probable service life of 12 months or more.

WELDING PIPE

The welding of odd-shaped pipes for cargo ships and tankers has been greatly speeded up by this War Production Suggestion of Fred Craytor, a welder at Marineship Corp., Sausalito, Calif.

A roller stand and positioner rotates the large, odd-shaped pipe so that the welding is easily and quickly accomplished. This device consists of a stand, welded from steel salvaged in the shipyard, which holds the various sizes of pipe securely against drive rollers by pressure rollers. The speed of the drive rollers and the rotation of the pipe are controlled by a foot throttle operated by the welder. This permits the welder to weld on top of the pipe, always in the most convenient downhand position.

The old method made it necessary to weld all around the pipe which was slow and often very difficult to reach points underneath. Frequently it required the use of chain blocks and small cranes in order to turn the pipe so that it might be welded.



Welding Pipe

The production of these odd-shaped pipes has been increased 33$^1/_3$% and, besides being a big safety factor, has completely eliminated the tying up of cranes during the welding.

Data and photo courtesy, The Hobart Brothers Co., Troy, Ohio.

LOW TEMPERATURE JOINING IN PRODUCTION

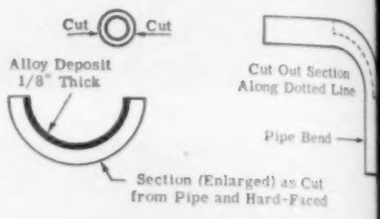
A new and attractive 4-page folder recently issued by the Eutectic Welding Alloys Co. explains the use of EutecRods and EutecTrodes in the production welding field.

Among the outstanding features claimed for the rods are: unusually low bonding temperatures that prevent distortion; less preheating of parent metal required; less after-machining and cleaning; establishes a greater strength than brazing, with less rejects; and insures a greater all-around economy during use.

Specific applications, uses and specifications on design and procedure of the various rods are also featured. A full-page assortment chart designed to aid engineers, technicians and welders in selecting the proper rod for their particular job is included.

Copies of "Eutectic Low Temperature Welding Alloys" can be secured, without charge, by writing directly to Department A-1, Eutectic Welding Alloys Co., 4 Worth St., New York 13, N. Y.

HARD FACING PIPE BENDS*

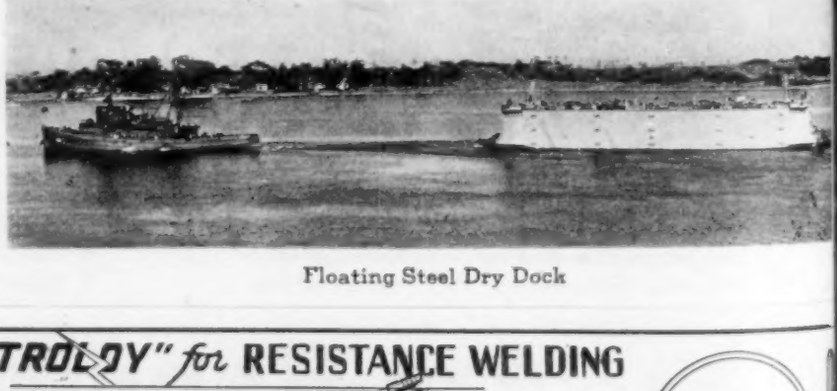


The inside surface of pipe bends in air conveyor lines can be hard faced inexpensively by cutting out the outer half of the bend of pipe, applying a $^1/_8$-in. deposit of chrome-cobalt-tungsten hard-facing alloy to the inner face of the pipe, and welding the piece back in place. The alloy is left as deposited.

* Reprinted from Welding "Sparks," Monthly Publication of the St. Louis Section of the American Welding Society, Vol. 1, No. 1, March, 1945

FLOATING STEEL DRY DOCK

This view illustrates the mobility of the repair equipment being built for the Navy. It shows a welded floating steel dry dock being towed away from the Chicago Bridge & Iron Co.'s yard at Eureka, Calif., where it was built. Official U. S. Navy Photo



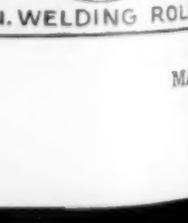
Floating Steel Dry Dock

"ELECTROLOY" for RESISTANCE WELDING

Butt
Flash
Spot
Seam
Projection

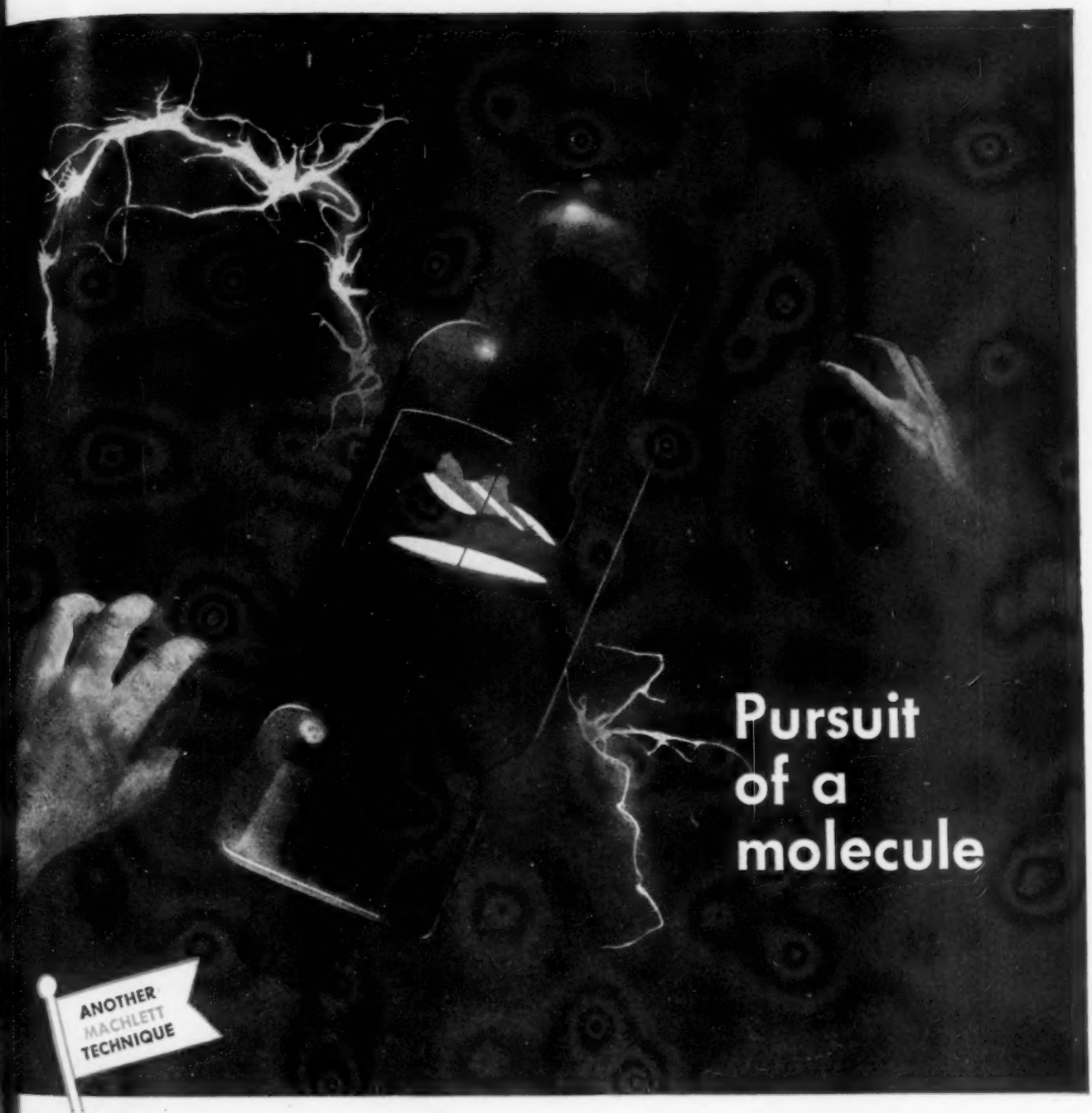
ELECTROLOY

Catalog and prices on request



OFFSET HOLDER

THE ELECTROLOY CO. INC. 1600 SEAVIEW AVE. BRIDGEPORT, CONN. WELDING ROLL



stable high vacuum is essential to the production of an electron tube if it is to give uniform, predictable performance. But there is much more to the process of getting a vacuum than just pumping.

Molecules of gas are not only present within the space inside the tube, and inside the metal parts, but also adhere tenaciously to all inner surfaces, or are "adsorbed". There is a special Machlett technique for dislodging those molecules. During pumping both the glass and the metal are brought to high temperatures. Cathode and anode are heated alternately many times, in order to capture molecules that are driven from one surface to the other. Most important of all, the tube is actually operated at voltages far in excess of values generally used in the vacuum tube field. All this takes many hours, the use of perfected apparatus including Machlett-designed pumps and other equipment, and the highest skills of laboratory-trained technicians.

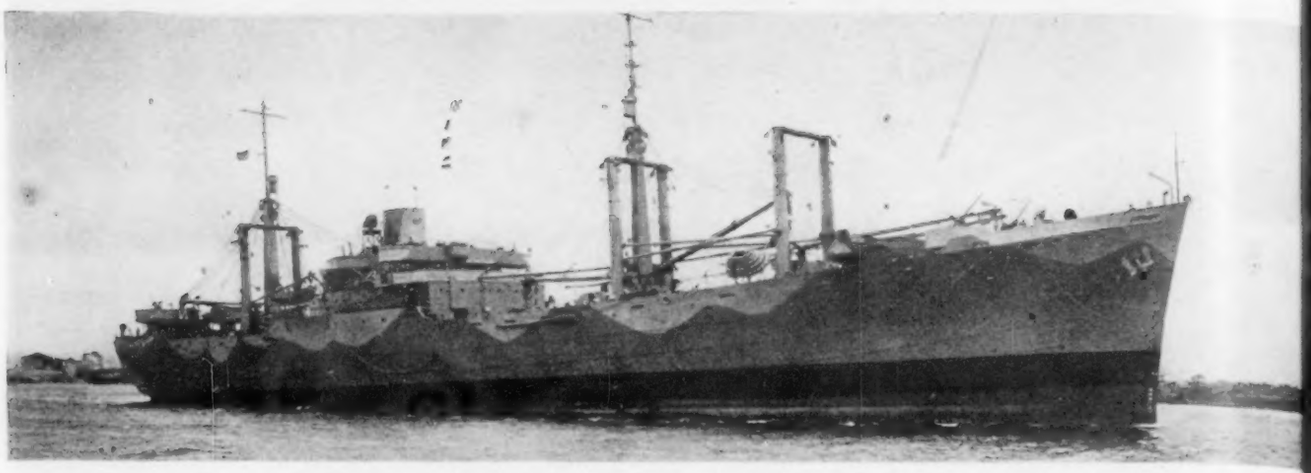
Thus when the tube is finally sealed we know the heat of operation cannot free enough molecules to affect its performance in your hands. This Machlett technique was developed for our X-ray tubes, and was in part responsible for the Machlett reputation. When we began the manufacture of radio and industrial oscillators, amplifiers and rectifiers, the same methods of capturing the molecules were adopted. That is one of the many reasons why users of Machlett radio and industrial tubes join with medical and industrial users of Machlett X-ray tubes in praising their reliability and economy. It will pay you to buy Machlett tubes. For information as to available types, write Machlett Laboratories, Inc., Springdale, Conn.

EG-50—an X-ray tube with beryllium window for radiography of light materials and thin sections.

MACHLETT

X-RAY TUBES SINCE 1897

TODAY THEIR LARGEST MAKER



U.S.S. *Bellatrix*—C-2 Class, 450 feet long, 90% welded

THE U.S.S. *BELLATRIX*

"The men and women, Tampa Shipbuilding Co., Inc.

"Special tribute to the performance of the U.S.S. *Bellatrix*, former Maritime Commission Hull 126, built in your yard, is contained in a report received from Vice-Admiral R. K. Turner, Commander of Amphibious Forces, U. S. Pacific Fleet. Admiral Turner states that this attack cargo ship has rendered consistently fine service in practically every major amphibious campaign against the Japanese.

"This AKA earned the title, 'Galloping Ghost of the Solomons Coast,' by successfully running the gantlet of enemy attacks many times in carrying vital supplies to our amphibious forces. The Bureau commends you for this excellent vessel.—E. L. COCHRANE, *Rear Admiral U.S.N., Chief of the Bureau of Ships.*"

"The Battlin' Bell"

By CAPTAIN H. R. TIETZ, USMCR
The Ship's Transport Quartermaster

Dedicated to
The Captain, Officers and Men
of the
U.S.S. *Bellatrix*

The wandering ghost of the Solomons Coasts
Came in again today;
Her holds had loads of stuff that explodes,
Her deck-load, too, was gay.

She had traveled bold with her valued load
All over the Coral swell;
Jap bombers sought, but all for naught,
To bottom "The Battlin' Bell."

A triple threat, a battle-scarred vet,
Alone today she arrived;
Cargo, tanker, cruiser, her role as each amused her
Of thrills she wasn't deprived.

Our fliers who espied "The Bell" on high
Let loose a mighty roar;
"Your fox holes, boys, there'll soon be noise
Of bombs and shells galore."

When'er "The Bell" came, the Japs did the same,
Hunting this mighty Queen;
The Marines disturbed and quite perturbed,
Shunned her as one unclean.

"The Bell" unloaded the stuff unexploded,
Finished the work begun;
Her head's now high, her jaunt's so spry,
The Admiral says: "Well Done."

WELDING MAGNESIUM ALLOY DIE CASTINGS*

In some castings $^3/_{16}$-in. thick with 10-32 tapped holes in them, the threads had been stripped and it was necessary to weld them up and retap them. A number of ways to weld them were tried but resulted in porosity in the weld metal due to the escaping gas from between the layers of the casting. Finally a successful weld was made by countersinking the hole and preheating about 1-in. diameter area around hole to allow gas to burn. After making the weld with low temperature alloy the metal was very readily tapped.

* Reprinted from Welding "Sparks," Monthly Publication of the St. Louis Section of the American Welding Society, Vol. 1, No. 1, March, 1945.

President Visits Louisville Section

The photograph above shows Mr. R. E. Fritsch, (left) President of Tube Turns and toastmaster of the Louisville Section of the A.W.S., and Mr. A. C. Weigel, (right) President of A.W.S., whom he introduced at the February meeting of the Louisville Section. Mr. Weigel was guest of Mr. Fritsch on a tour of the Tube Turns plant during his visit.

Employment Service Bulletin

POSITION VACANT

V-158. Welder Foreman. Experienced man thoroughly familiar with acetylene welding of carbon steel and stainless steel sheet metal parts for aircraft. Must have proved supervisory experience and capable of instructing welder-trainees. Write giving full particulars as to age, experience and salary desired.

WANTED—WELDING EDITOR

V-160. Preferably a man of about 30 to 35 years of age. Wide knowledge of welding with editorial background to assist committees in the preparation of engineering information on welding. State full experience and salary desired. Permanent position for right man.

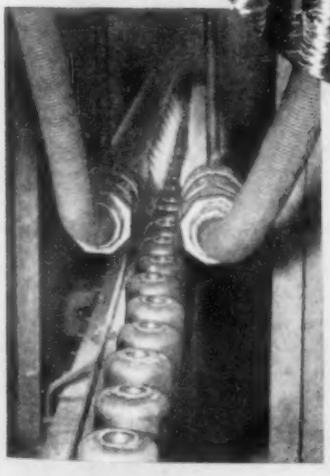
SERVICES AVAILABLE

A-497. Metallurgist desires position. Age 27. Draft status 2B until July 1945. No physical defects. Graduated 1939 University of Michigan, B.S. in Metallurgical Engineering. Graduate work, Lehigh University, 1939 to 1940. Junior Metallurgist, National Tube Co., 1940 to 1942; Assistant Welding Engineer, Industrial Test Laboratory, Philadelphia Navy Yard, to November 1944. At present Metallurgist with Crucible Steel Co. Would like position utilizing experience in welding research work.

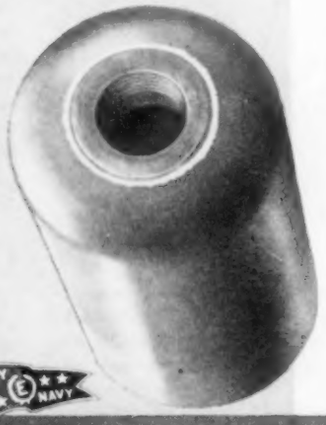
A-498. Welding Shop Superintendent with ten years' practical experience in oxy-acetylene, arc welding and burning. Now employed as Superintendent of Shop doing low-pressure tank work. Ability to set up production procedures and handle men. Considerable mechanical experience which should be helpful in product development. Also experienced in other tank shop operations, maintenance and job shop welding and two years of machine shop work.

HOW TO GET A STEADY STREAM OF RELIABLY BRAZED PARTS *with* SIL-FOS *or* EASY-FLO

At left — Adapter, EASY-FLO wire ring and hand grenade body. Bodies are carried on a simple conveyor, first through a liquid degreaser and then past stations where they are progressively fluxed, adapters are inserted and EASY-FLO rings are preplaced. Assemblies then enter the heating section where they are rotated as they move along.



At left — The rotating assemblies are carried between two rows of gas-air burners. Time per body through the heating section—only 63 seconds. Production is 660 per hour, with the human element eliminated from the actual brazing.



Thousands of SIL-FOS and EASY-FLO users have worked out effective methods of taking full advantage of the fast brazing action of these low temperature silver alloys. Out of these methods has come a clear-cut *basic procedure* which can be readily adapted to obtain any required brazing production. Here are the simple basic steps to follow:

1. *Preplace the alloy* at the joints in wire, wire ring, washer or strip form, depending on the type of joint.
2. Use a *fast handling set-up* to keep parts moving steadily through cleaning, fluxing, assembling and heating operations.
3. Use a *fast heating method*—oxyacetylene torch, furnace, induction, gas-air, etc., preferably with the heating time and temperature under automatic control.

An example of the effective application of this procedure is illustrated—the brazing of adapters to hand grenade bodies. With a simple conveyor set-up and gas-air heating, a production of 660 brazed assemblies per hour is readily maintained.

GET THE FULL STORY IN THESE TWO BULLETINS

BULLETIN 12-A tells you all about SIL-FOS and EASY-FLO and the reasons for their remarkable brazing speed, strength, reliability and economy. Also gives you a lot of valuable information on joint designs, heating methods, etc.

The SILVER ALLOY BRAZING reprint gives you the full story of the hand grenade job and describes a number of other jobs on which similar fast production methods were used.

Write for copies of these two bulletins today.

ARMY E NAVY

HANDY & HARMAN

HANDY & HARMAN FOUNDED 1867 QUALITY SERVICE

82 FULTON ST., NEW YORK 7, N. Y.

Bridgeport, Conn. • Chicago, Ill. • Los Angeles, Cal. • Providence, R. I. • Toronto, Canada

Agents in Principal Cities

NEW PRODUCTS

The Society assumes no responsibility for the validity of claims in this Section

MULTI-PURPOSE WELDING POSITIONER

The latest design in powered welding positioners is introduced by the Standard Machinery Co. of Providence, R. I., for rotating work up to 700 lb. at speeds from 0 to 2.4 rpm. in either direction by easy hand wheel control. The unit will accommodate table speeds up to 180 in. per minute with a work radius of 1 ft. Linear speeds at all radii are easily set and indicated on scale located on side of frame.

The machine has proved adaptable for moving work past the torch and quench in flame-hardening operations. The table can be removed easily and various jigs attached directly to the spindle. Also, the work mounted on positioner table may be tilted to any angle, permitting worker to operate at one position and so facilitate the inspection of parts or assembly operations.

Height of the table is adjusted between 30 and 36 in. from the floor by means of its elevating screw. Hand operation of a latch permits rotation of the screw with respect to its supporting sleeve, in a manner similar to the raising or lowering of a piano stool.

Tilting of the table through 135° from the horizontal is controlled by a spring-centered handle which the operator moves through an angle of approximately 45° in the direction of the desired table movement. Automatic limit stops are provided.

The mechanism of the machine is enclosed entirely for safe operation. There are no exposed gears. All moving parts are protected against splash from molten weld rods.

MULTIPLE STUD WELDER PRODUCTION UNIT

A new automatic stud welding development to meet mass production requirements is the Nelson Multiple Stud Welder Production Unit. Using this unit two or more studs may be welded in one operation. The work is rapidly performed and the studs are held to very close tolerances.

Each of the welding guns is mounted on a pneumatic air cylinder. Each cylinder is fixed to a movable arbor which can be adjusted to any spacing necessary for the work.

The work is held in a mandrel, chuck or special locating device—the setup being determined by the particular production problem at hand. The welding current is obtained from a conventional 400-amp. generator, and is regulated by a timing control unit which automatically controls the length of arc flow, producing controlled and consistent welds.

The Multiple Welding Unit is operated with a single control switch. The work is inserted, stud is fitted into the chuck of each stud welding gun and the control switch pressed. The first gun then descends making a weld. Upon completion of this weld the next gun descends and welds. The guns then ascend automatically and the work is removed.

Each production unit is manufactured only on order to permit the unit to be made to fit the particular problem. For complete details and prices write Nelson Specialty Welding Equipment Corp., 440 Peralta Ave., San Leandro, Calif.

RESISTANCE WELDING CONTROLS

More than 150 different combinations of Westinghouse Industrial resistance welding control will soon be possible from only eleven standard basic units. From these units it will be possible to factory assemble welding controls that will meet the diversified needs of industry which at present are only available through individually designed and custom-built controls. Here T. R. Lawson, Resistance Welding Application Manager, uses planning models to demonstrate the ease and simplicity of building up any wanted control.

NEW SOAPSTONE CRAYON FOR METAL WORKERS

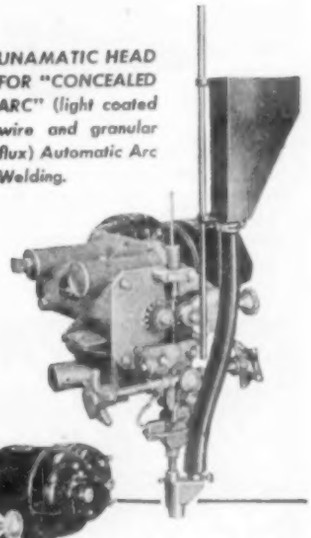
Because of heavy demand, producers and distributors of metal workers' crayons have been unable to reduce the heavy backlog of orders. To alleviate the situation, Whittaker, Clark & Daniels, Inc., distributors of crayons, started experiments to develop a satisfactory substitute which would be equal in quality, if not better, than the natural soapstone crayon. As a result, there is now on the market a "Steelrite" brand soapstone metal workers' crayon made from genuine powdered "soapstone sawdust," which was a waste product of the cuttings of natural crayons.

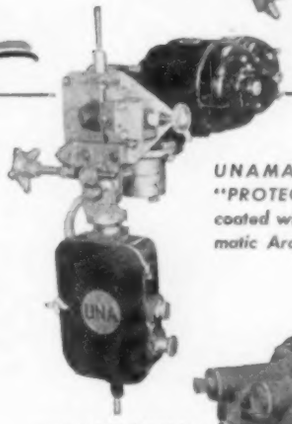
The manufacturer of "Steelrite" crayons states that these new crayons wear 20% slower than the natural crayons, weigh approximately 35% less and contain no wax binder. It is claimed that they mark well on damp, grimy, hot or cold surfaces, and will sharpen to a long-wearing, marking edge that will not flake in use. Because of their uniformity of strength, freedom from grit (hard spots), they are economical to use, as they are serviceable down to the last inch. Furthermore, the markings made with this new crayon hold to the metal surface better than those made with the natural product.

Further information can be obtained from Whittaker, Clark & Daniels, Inc., 260 West Broadway, New York 13, N. Y.

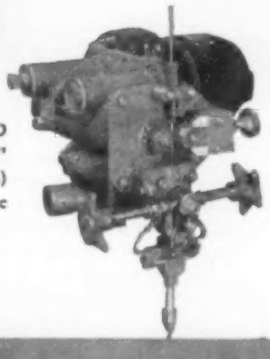
it's time to change....

UNAMATIC HEAD FOR "CONCEALED ARC" (light coated wire and granular flux) Automatic Arc Welding.





UNAMATIC HEAD FOR "PROTECTED ARC" (light coated wire and tape), Automatic Arc Welding.



UNAMATICHEAD FOR "OPEN ARC" (light coated wire) Automatic Arc Welding.

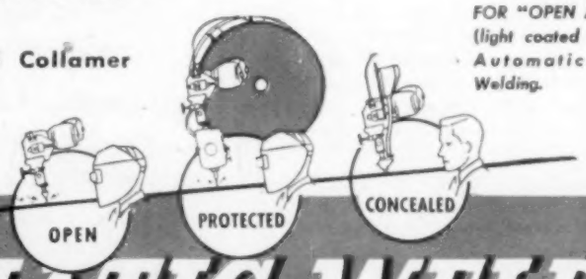
MANY old-fashioned fabrication methods are as antiquated as the proverbial suit of red flannel underwear when compared with the modern Unamatic Arc Welding processes.

Whether you are using arc welding or not, if you have a metal fabricating or repetitive repair problem, it will pay to get the facts on Unamatic Welding.

Unamatic Welding speeds production, reduces production costs, improves the quality of work, when compared with other fabricating methods.

Since *it's time to change,* write for the facts ... today.

UNA WELDING, INC. • 1615 Collamer Avenue • Cleveland 10, Ohio



UNAMATIC WELDING

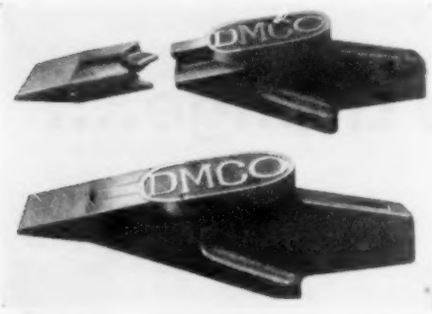
TWO-PIECE DIPPER TOOTH

The new two-piece dipper tooth pictured, which was recently developed by the Daniels-Murtaugh Co., presents improvements for this type of equipment which recommends its use on a wide range of digging and loading equipments, such as dippers, clamshell and dragline buckets and trencher buckets.

The two parts of the "Wear-Sharp Tooth" (patent pending), shown, are designated as the "Penetrater Point" and the "Weldapter." The design makes it extremely easy to replace the point, which is double keyed to the Weldapter and tack welded. When the point becomes worn, it is readily removed and a new point installed by simply slipping it on the Weldapter and tack welding at several points along the side and across the end where the parts join. The welds hold the point in place only. The double-key supports, one lengthwise and one crosswise of both parts, take all the digging stresses upward and downward, as well as side thrusts and impact shocks.

Obviously there is a considerable saving in welding materials and manhours when these teeth are used.

For further information, write the Daniels-Murtaugh Co., 625 C Avenue, N.W., Cedar Rapids, Iowa.

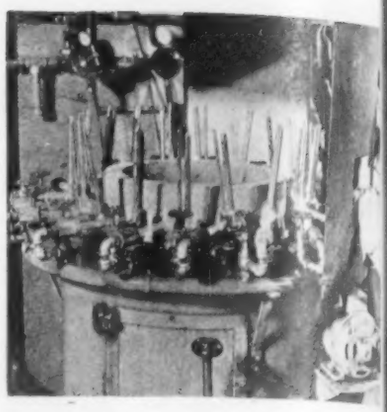


"Wear-Sharp Tooth" (Patent Pending) for Power Shovel Dippers and Dragline Buckets, Made in Two Parts Consisting of Penetrater Point and Weldapter. Penetrater Point Can Be Readily Replaced When Worn.

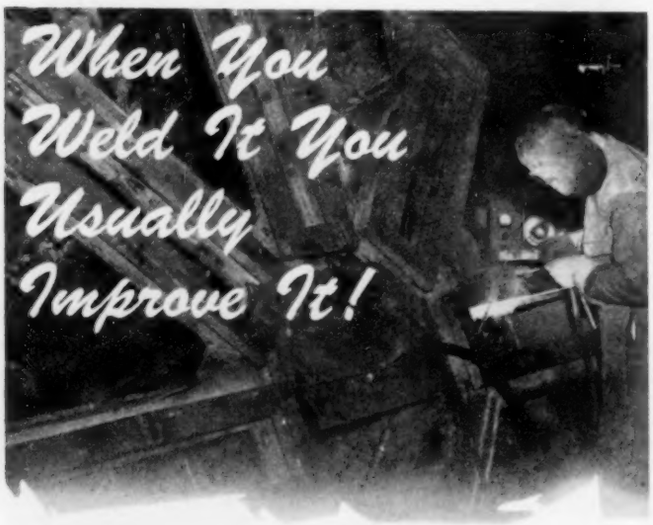
SILVER SOLDERING MACHINE ASSURES UNIFORM HEATING

By W. L. Ulmer, President, Superior Flux Co., Cleveland, Ohio

Uniform and controlled heating of the work pieces in silver soldering operations is accomplished by the use of this rotating work table, in the plant of Smith Welding Equipment Corp., Minneapolis, Minn. The machine is operated by two electric motors. One motor, with variable speed, operates the turntable which passes the pieces to be silver soldered through the various flames. The second motor rotates the pieces at a fixed speed in the holders so that they are heated uniformly all the way around. Adjustment of the turntable speed further provides for a uniform and gradual rate of heating to the soldering temperature. The flux is thus brought to the right temperature at the right time, without being overheated.



The turntable rotates in a counter-clockwise direction and soldering is done by the operator seated at the right. The operator standing removes the piece after it has been soldered and puts an unsoldered piece in its place. The photograph shows tubes being soldered into the head of Smith "Lifetime" cutting assemblies. Actually, two silver soldering operations are being performed at the same time, one a manual operation and the other automatic. One of the inserted tubes encloses a smaller tube which carries the oxygen for the preheating flame. This preheating oxygen tube is screwed into the head and a small ring of silver solder is fitted around where the joint is going to be. Then the joint is fluxed with Superior No. 6 solder



This is particularly true of machine tool bases, frames, levers; of diesel engine frames and gear casings; equipment for paper mills; crane and hoist parts; manifolds, blower housings; parts for the great majority of electrical appliances, etc.

Welded construction is almost always stronger, yet lighter—also more sightly and often less costly.

Study your product. Arrange to weld as much of it as possible. Consult United engineers on new plans, or submit present plans for study and estimates.

THE UNITED WELDING CO.
MIDDLETOWN, OHIO
WELDING FABRICATORS OF MODERN DESIGNS
Since 1913

PRACTICAL DESIGN OF WELDED STEEL STRUCTURES

by H. M. Priest

An up-to-date book of 150 pages copiously illustrated with charts and photos giving practical design information and procedures for the design of welded steel structures. Price $1.00. Bound in cloth covers.

AMERICAN WELDING SOCIETY
33 WEST 39TH STREET, NEW YORK 18, N. Y.

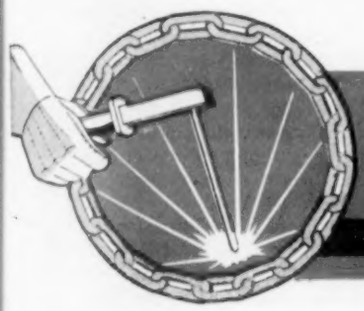
McKAY *Stainless Steel* ELECTRODES

McKAY GRADE	A.I.S.I. TYPE No.	USE AND CHARACTERISTICS	SIZES
18-8	308	For welding Stainless Steels from 17 Chrome, 7 Nickel to 20 Chrome, 10 Nickel. Weld metal will be equal or superior to parent metal in corrosion and physical properties.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
25-12	309	For welding type No. 309 Stainless Steel and stain clad plate where higher Chrome Nickel content is desired than can be secured with 18-8 Electrodes.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
25-12 Cb	309 Cb	For welding type 309 Cb Stainless Steel and for multiple pass weld where interpass temperature may be up long enough for carbides to form.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
25-20	310	For welding type 310 Stainless Steel. Also widely used for welding plain Carbon Steel up to .50 Carbon and low Chrome Steels where post heat treatment is not practical.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
18-8 Mo	316	For welding type 316 Stainless Steels. Molybdenum content of weld deposit 2 to 3%.	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
18-8 Mo	317	For welding type 316 or 317 Stainless Steels. Molybdenum content of weld deposit 3 to 4%.	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
15-35	330	For use on type 330 Stainless Steels where welds are subject to extremely corrosive agents or require heat resistance up to 2100°F.*	3/32"—1/8" —5/32" 3/16"
18-8 Cb	347	For welding type 347 and 321 Stainless Steels where welds may be exposed to service temperatures between 900°-1500°F.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
12 Cr	410	For welding type 410 Chromium Steels. Weld structure is martensitic requiring preheat and post heat treatment to refine grain structure.*	3/32"—1/8" —5/32" 3/16"
16 Cr	430	For welding type 430 Chromium Steels. Weld structure is normally ferretic. Preheat and post heat treatment required to eliminate stresses.*	3/32"—1/8" —5/32" 3/16"
18 Cr	442	For welding type 442 Chromium Steels. Weld structure is ferretic and subject to grain growth. Preheat and post heat treatment required to eliminate stresses.*	3/32"—1/8" —5/32" 3/16"
28 Cr	446	For welding type 446 Chromium Steels. Weld structure is ferretic and subject to grain growth. Preheat and post heat treatment required to eliminate stresses.*	3/32"—1/8" —5/32" 3/16"
5 Cr Mo	502	For welding type 501 and 502 Chromium Steels. Weld structure is martensitic requiring preheat and post heat treatment, to refine grain structure.	3/32"—1/8" —5/32" 3/16"
15-60	....	For welding Nichrome Steel and similar compositions requiring toughness, resistance to oxidation, nitriding and carburization.	1/8" —5/32"—3/16"
Frogalloy	....	Weld deposit of work hardening type. Used for building up wearing surfaces subject to impact.	1/8" —5/32"—3/16" 1/4"
Tool and Die	....	For repair and build up of air hardening tools and dies. Has good abrasion resistance properties.	3/32"—1/8" —5/32" 3/16"
Armorloy A-8	....	For welding Armor Plate and other difficult weldable alloys. Has high resistance to weld cracks when used with dissimilar alloys.	3/32"—1/8" —5/32" 3/16"—1/4" —5/16" 3/8"

*These Electrodes are supplied with Titania coating for DC reverse polarity unless otherwise specified. They are available in Lime coating for DC or AC and in a special Titania coating for AC on request.

The Titania coating for DC reverse is green in color. The Lime coating for DC or AC is grey in color. The Titania coating for AC is cream in color.

GENERAL SALES OFFICES: YORK, PA.



THE McKAY COMPANY
PITTSBURGH, PA.

WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

TWO-PIECE DIPPER TOOTH

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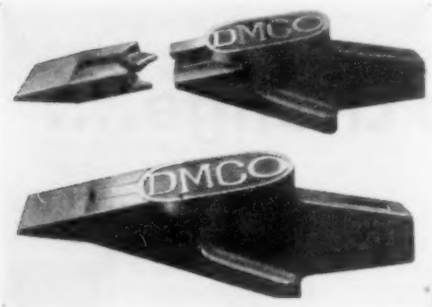
Obviously there is a considerable saving in welding materials and manhours when these teeth are used.

For further information, write the Daniels-Murtaugh Co., 625 C Avenue, N.W., Cedar Rapids, Iowa.



"Wear-Sharp Tooth" (Patent Pending) for Power Shovel Dippers and Dragline Buckets, Made in Two Parts Consisting of Penetrater Point and Weldapter. Penetrater Point Can Be Readily Replaced When Worn.

SILVER SOLDERING MACHINE ASSURES UNIFORM HEATING

By W. L. Ulmer, President, Superior Flux Co., Cleveland, Ohio

Uniform and controlled heating of the work pieces in silver soldering operations is accomplished by the use of this rotating work table, in the plant of Smith Welding Equipment Corp., Minneapolis, Minn. The machine is operated by two electric motors. One motor, with variable speed, operates the turntable which passes the pieces to be silver soldered through the various flames. The second motor rotates the pieces at a fixed speed in the holders so that they are heated uniformly all the way around. Adjustment of the turntable speed further provides for a uniform and gradual rate of heating to the soldering temperature. The flux is thus brought to the right temperature at the right time, without being overheated.

The turntable rotates in a counterclockwise direction and soldering is done by the operator seated at the right. The operator standing removes the piece after it has been soldered and puts an unsoldered piece in its place. The photograph shows tubes being soldered into the head of Smith "Lifetime" cutting assemblies. Actually, two silver soldering operations are being performed at the same time, one a manual operation and the other automatic. One of the inserted tubes encloses a smaller tube which carries the oxygen for the preheating flame. This preheating oxygen tube is screwed into the head and a small ring of silver solder is fitted around where the joint is going to be. Then the joint is fluxed with Superior No. 6 solder

This is particularly true of machine tool bases, frames, levers; of diesel engine frames and gear casings; equipment for paper mills; crane and hoist parts; manifolds, blower housings; parts for the great majority of electrical appliances, etc.

Welded construction is almost always stronger, yet lighter—also more sightly and often less costly.

Study your product. Arrange to weld as much of it as possible. Consult United engineers on new plans, or submit present plans for study and estimates.

ARMY E NAVY

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THE UNITED WELDING CO.
MIDDLETOWN, OHIO

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by H. M. Priest

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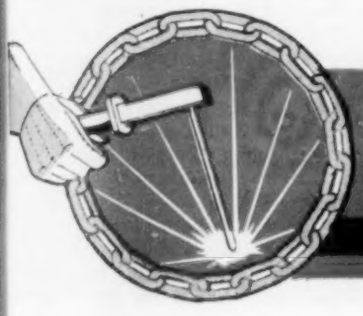
AMERICAN WELDING SOCIETY
33 WEST 39TH STREET, NEW YORK 18, N. Y.

McKAY *Stainless Steel* ELECTRODES

McKAY GRADE	A.I.S.I. TYPE No.	USE AND CHARACTERISTICS	SIZES
18-8	308	For welding Stainless Steels from 17 Chrome, 7 Nickel to 20 Chrome, 10 Nickel. Weld metal will be equal or superior to parent metal in corrosion and physical properties.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
25-12	309	For welding type No. 309 Stainless Steel and stain clad plate where higher Chrome Nickel content is desired than can be secured with 18-8 Electrodes.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
25-12 Cb	309 Cb	For welding type 309 Cb Stainless Steel and for multiple pass weld where interpass temperature may be up long enough for carbides to form.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
25-20	310	For welding type 310 Stainless Steel. Also widely used for welding plain Carbon Steel up to .50 Carbon and low Chrome Steels where post heat treatment is not practical.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
18-8 Mo	316	For welding type 316 Stainless Steels. Molybdenum content of weld deposit 2 to 3%.	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
18-8 Mo	317	For welding type 316 or 317 Stainless Steels. Molybdenum content of weld deposit 3 to 4%.	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
15-35	330	For use on type 330 Stainless Steels where welds are subject to extremely corrosive agents or require heat resistance up to 2100°F.*	3/32"—1/8" —5/32" 3/16"
18-8 Cb	347	For welding type 347 and 321 Stainless Steels where welds may be exposed to service temperatures between 900°-1500°F.*	1/16"—5/64"—3/32" 1/8" —5/32"—3/16" 1/4"
12 Cr	410	For welding type 410 Chromium Steels. Weld structure is martensitic requiring preheat and post heat treatment to refine grain structure.*	3/32"—1/8" —5/32" 3/16"
16 Cr	430	For welding type 430 Chromium Steels. Weld structure is normally ferretic. Preheat and post heat treatment required to eliminate stresses.*	3/32"—1/8" —5/32" 3/16"
18 Cr	442	For welding type 442 Chromium Steels. Weld structure is ferretic and subject to grain growth. Preheat and post heat treatment required to eliminate stresses.*	3/32"—1/8" —5/32" 3/16"
28 Cr	446	For welding type 446 Chromium Steels. Weld structure is ferretic and subject to grain growth. Preheat and post heat treatment required to eliminate stresses.*	3/32"—1/8" —5/32" 3/16"
5 Cr Mo	502	For welding type 501 and 502 Chromium Steels. Weld structure is martensitic requiring preheat and post heat treatment, to refine grain structure.	3/32"—1/8" —5/32" 3/16"
15-60	....	For welding Nichrome Steel and similar compositions requiring toughness, resistance to oxidation, nitriding and carburization.	1/8" —5/32"—3/16'
Frogalloy	....	Weld deposit of work hardening type. Used for building up wearing surfaces subject to impact.	1/8" —5/32"—3/16" 1/4"
Tool and Die	....	For repair and build up of air hardening tools and dies. Has good abrasion resistance properties.	3/32"—1/8" —5/32" 3/16"
Armorloy A-8	....	For welding Armor Plate and other difficult weldable alloys. Has high resistance to weld cracks when used with dissimilar alloys.	3/32"—1/8" —5/32" 3/16"—1/4" —5/16" 3/8"

*These Electrodes are supplied with Titania coating for DC reverse polarity unless otherwise specified. They are available in Lime coating for DC or AC and in a special Titania coating for AC on request.

The Titania coating for DC reverse is green in color. The Lime coating for DC or AC is grey in color. The Titania coating for AC is cream in color.



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THE McKAY COMPANY
PITTSBURGH, PA.

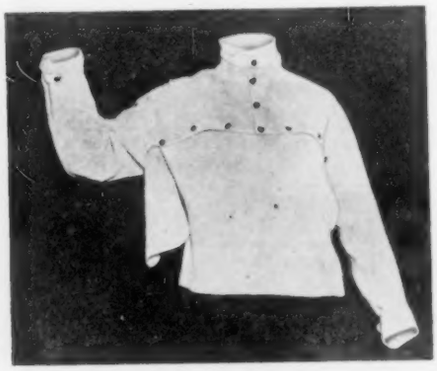
WELDING ELECTRODES . . . COMMERCIAL CHAINS . . . TIRE CHAINS

flux and the outer tube is screwed into place. This same procedure is followed when the tubes are soldered into the butt, except that the tubes are not screwed but pressed into place. The silver solder is applied to the two outside joints in the form of a wire fed continuously by hand, while the inner joint is heated by conduction so that the joint is automatically soldered.

The small tube, which carries the preheating oxygen inside of the larger tube, is of copper. The larger tube is of monel metal, except when the scarcity of that alloy makes it necessary to use drawn brass. The oxygen tube at the top of the cutting assembly is a drawn brass tube. Heads and butts are bronze forgings.

WELDING CAPE

This new garment for welders gives full protection when welding in all positions. Made of high-grade, durable, chrome leather, incorporating underarm flaps and a collar which may be turned up, the wearer is completely protected even when doing overhead welding. The collar is securely held in an upright position by means of special tabs and a snap fastener.



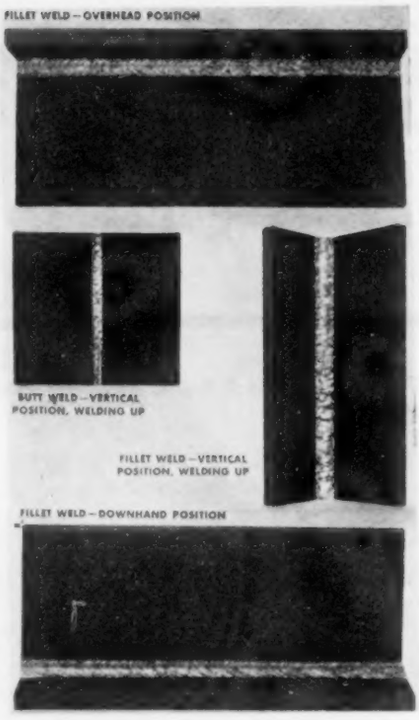
In addition, the design provides freedom of movement and ventilation. Bib front is equipped with snap fasteners for easy removal. For further information, write to Eastern Equipment Co., Inc., Willow Grove, Pa.

ALL-POSITION WELDING ELECTRODE

A new shielded arc electrode for general purpose welding of mild steel which offers a number of outstanding advantages over existing electrodes of the same classification is announced by The Lincoln Electric Co., Cleveland, Ohio.

The new electrode, designated as "Fleetweld 47," offers such advantages as extremely low spatter loss, easy slag removal (most welds are practically self-cleaning), excellent re-striking characteristics, and other improved features.

"Fleetweld 47" conforms to AMERICAN WELDING SOCIETY electrode specifications Class E-6012 and Class E-6013 and may be used with either alternating or direct current. "Fleetweld 47" is especially well suited for making high-speed horizontal or flat fillet welds over 4 in. long in which the


FILLET WELD – OVERHEAD POSITION
BUTT WELD – VERTICAL POSITION, WELDING UP
FILLET WELD – VERTICAL POSITION, WELDING UP
FILLET WELD – DOWNHAND POSITION

Specimen Welds Produced with the New Lincoln "Fleetweld 47" Shielded Arc Electrode

coating can be dragged on both plates. It has also been used extensively for both vertical and overhead fillets, especially where large single pass fillets are desired.

The ease of complete slag removal on square edge butt welds makes "Fleetweld 47" exceptionally excellent for this type of joint. Complete penetration of $^1/_4$-in. plate can be obtained by welding one pass from each side.

This new electrode is available in the following sizes: $^5/_{32}$ x 14 in., $^3/_{16}$ x 14 in., $^1/_4$ x 18 in. and $^5/_{16}$ x 18 in. The electrodes are packed in 50-lb. containers.

HYDRAULIC ELEVATING TABLE

Lyon-Raymond Corporation, 2155 Madison St., Greene, N. Y., have added another optional feature—a telescopic towing handle—to their popular hydraulic

elevating table. Extended, the handle provides means for easily moving the table from place to place. Collapsed, the handle is below and under the table top where it will not interfere with operations involving the transfer of materials across the table or the support of overhanging pieces.

The table can be readily maneuvered without the use of the handle, but long hauls are easier with it.

Other optional features have been available for some time. These are: (1) two-speed pump in place of single-speed; (2) retaining bars; (3) removable roller top; (4) indexing device. Like them, the telescopic towing handle is designed to further increase the usefulness of the hydraulic elevating table in a wide range of material handling operations.

NEW BATTERY WELDER GIVES SPECTACULAR SERVICE ON TOUGH JOB

Only recently announced by Progressive Welder Co., Detroit, the spectacular new Storage Battery operated welders which do not require special power lines are already in action turning out war matériel. Among early installations is that shown here, turning out fluted structural steel Naval ordnance sections 20 hr. a day at a rate of 1440 spot welds per hour.

The machine—one of the "smaller" models of Progressive Storage Battery Welders—is installed in a plant having only a limited amount of power available (certainly not enough to operate the 150-

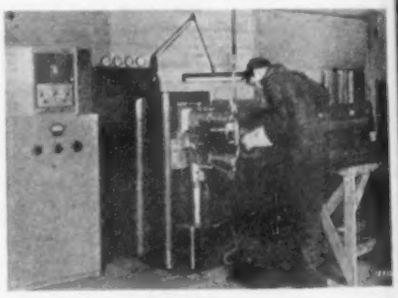


Fig. 1—Battery Welder, with Monorail Quick-Clamp Fixture, Making $^1/_4$-In. Thick Welds in Structural Steel at the Rate of 29,000 Every 20 Hr., on a Maximum Input of 26.7 Kva.

kva. machines which would be the minimum required if conventional welders were to be used on such a job). It is coupled direct to the 220-volt shop wiring system through a battery charger which has a maximum 3-phase draw of only 26.7 kva.

The parts being welded ($^1/_8$ to $^1/_4$ steel) are arc tacked before coming to the welder. Some 240 spot welds are required to finish each assembly. Output is approximately 6 units per hour, equivalent to a day's output of some 29,000 welds. To facilitate handling, the unit to be welded is mounted in a swiveling quick-clamp fixture suspended through springs at approximate welding height from an overhead monorail.

To weld, the operator loads the part onto the fixture, slides it into position for the first weld and steps on the treadle control to start operation of the simpler timer

Every One a CHAMPION

PRESENTING OUR COMPLETE LINE OF WELDING ELECTRODES

Mild Steel Electrodes

BLUE DEVIL	All Position, Reverse Polarity	A. W. S. 6010
BLUEDAC	All Position, A. C. Current	A. W. S. 6011
GRAY DEVIL	General Purpose, Poor Fit-up Straight Polarity	A. W. S. 6012
GRAY DEVIL No. 2	General Purpose, Smooth Bead Straight Polarity Also A. C. Current	A. W. S. 6013
BLACK DEVIL . . .	Deep Grooves and Horizontal Fillets Straight Polarity	A. W. S. 6020
RED DEVIL	Deep Grooves, Reverse Polarity	A. W. S. 6030
BLACK DEVIL F. B.	Finishing Beads for Smooth Cover Beads	A. W. S. 6030

High Tensile Electrodes

BLUE DEVIL 85 . .	All Position, Reverse Polarity	A. W. S. 7010
RED DEVIL 75 . . .	Deep Grooves and Horizontal Fillets . . .	A. W. S. 7020 A. W. S. 7030

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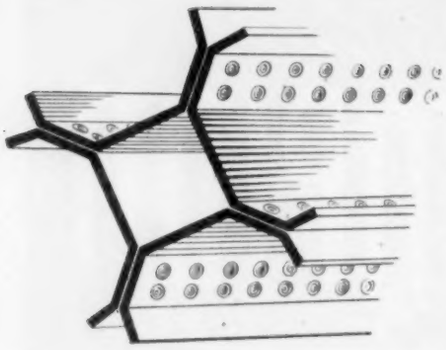

Fig. 2—Sketch of Structural Ordnance Sections Being Produced on Battery Welder

shown at the left above the charger cabinet. Operation from here is continuous (automatic repeat) as long as the operator keeps pressure on the treadle. Just enough of an interval is allowed by the timer between welds to shift to the next weld position (a matter of only 1/4 sec.). On completion of all spots on one web, the assembly is flipped 90° in the fixture to weld up the next web. Welding time is approximately 1/2 sec.

The welder itself is of the rocker arm type, with batteries located in the base of the machine in place of the conventional transformer. The air-actuated contactor-controller which operates on the carbon-pile principle is also located in the base of the machine. With this type of contactor, it is the actual welding current rather than the "primary" current which is interrupted. The amount of current is controlled by the pressure between the two carbon disks in the contactor-controller. (The greater the pressure the less resistance and the greater the current.) When the pressure is removed, current stops flowing, permitting opening of the contactor by separating the carbon disks without arcing, despite the fact that welding current is around 20,000 amp.

An unusual feature is that no compensation is required for induction losses from the first to the last weld in the assembly. Since direct current is used for welding, the amount of stock in the throat of the welder has little effect on welding current, there being no induction losses to all practical purposes.

Although in continuous operation, the 12 battery cells are kept charged by the automatic charger with its peak draw of 80 amp., three phase. Service requirements to date have consisted mainly of adding water to the battery about once every three weeks, and occasional point dressing.

AIR-FED HELMET

To give welders complete relief from abnoxious fumes, a new air-fed welding helmet has been designed by a group of doctors and safety engineers. The helmet was originated by the Pullman Standard Car Manufacturing Co., Chicago, with the aid of the Northwestern University Medical School.

After exhaustive tests in many large plants, it is reported that the new helmet reduces worker fatigue and improves worker morale. Surprising production increases also result, the tests showed.

Clean, fresh air is scientifically fed into the helmet, through a supply tube encircling the lens holder. Air flows gently along the shell and travels to every outer edge. Air constantly circulates within the helmet, yet uncomfortable, cold-encouraging drafts are eliminated. The directional flow of the fresh air prevents stale or fume-laden air from entering. Heat is cut down. Welders work in comfort under all conditions.

Following original design by Pullman Standard doctors and Northwestern University medics, the helmet has been developed and perfected by the Chicago Eye Shield Company. It is identified by the name, Cesco "Air-Flow" Welding Helmet. For further information, write Chicago Eye Shield Co., 2300 Warren Blvd., Chicago 11, Ill.

BRAZING INDUCTION EQUIPMENT

Illustrated is a new 24-station circular indexing carrier mounted on one of the company's 18-kw. electronic high-frequency generators to braze metal assemblies. A complete assembly is ejected from the carrier each 12 seconds. The operator's activities are limited to loading the stations as they come around empty. Heat is applied by a set of three water-cooled induction coils located under three of the work positions. The coils are followed by the vertically operating ejecting mechanism. Carrier drive is by a small motor.

Application of the carrier can be made on any of the company's electronic generators with ratings of 5 to 100 kw. depending on the heat-input requirements of the work. Normal output of the unit is at 200 to 600 kilocycles.

Write to Scientific Electric Division of "S" Corrugated Quenched Cap Co., 107-119 Monroe Street, Garfield, N. J., for further information.

QUALITY CONTROL FOR RESISTANCE WELDING OF SWITCHGEAR

A system of quality control of resistance welding that has been used successfully for over two years in manufacturing switch gear cubicles and equipment is the subject of an A.I.E.E. Spring Program paper by R. S. Inglis, R. P. McCants and L. S. Hobson of the Switchgear Division, General Electric Company. Stating that standardization of the process is essential to its control, the authors describe in detail the methods by which it is attained.

Although on highly repetitive jobs it is necessary to establish the proper welding procedure only once and continue on that basis for the duration of the job, variable welding conditions such as are encountered in the fabrication of switchgear equipment make it necessary to have a specific procedure for each combination of materials. In the absence of basic fundamental data for such conditions, the authors state that it was originally necessary to undertake an extensive program to determine the effects of such variables as material type and thickness, welding current, pressure and time. Many thousands of tests were made in which these factors were independently varied, and from this study it was possible to establish the proper welding procedures and the physical properties of the welds. These methods of testing and control continue in use today.

The authors report that since the structural stability of assemblies which are fabricated by resistance welding depends not only upon the quality of the parts used but upon the strength and ductility of the welds—two things which are most difficult to determine without destruction of the fabricated parts—three welded specimens are prepared each hour under the same conditions of production welding. These specimens are tested in torsion in special testing machines to determine ultimate torque, angle of twist and weld diameter.

AO NOVIWELD-DIDYMIUM LENSES

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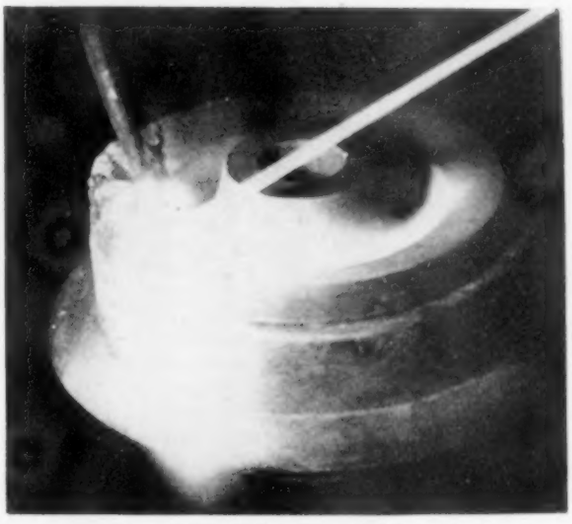
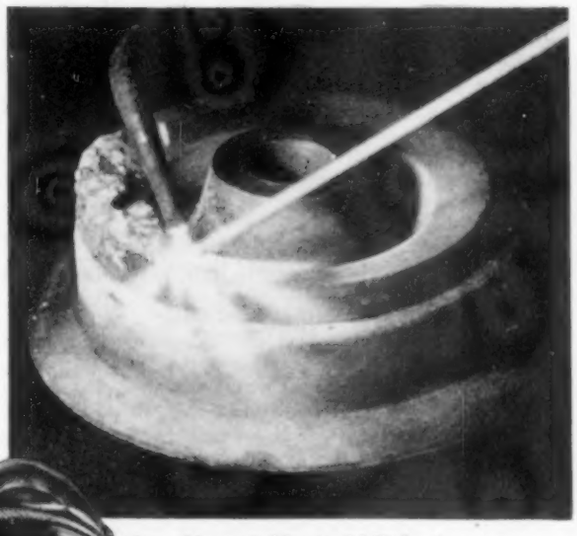
- They protect against ultra-violet and infra-red radiations
- They are ground and polished to ophthalmic standards

Available in shades 3, 4, 5 and 6



Seen Through Standard Welding Glass



Seen Through Noviweld-Didymium

With a clearer picture of his work, the welder can lay cleaner beads. As a result, secondary operations—chipping, grinding and wire brushing—cost less.

Let an AO Safety Engineer give you a demonstration. Phone or write your nearest AO Branch Office.

AO Duraweld Goggles are available with* Noviweld-Didymium *lenses

American Optical
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SOUTHBRIDGE, MASSACHUSETTS

SECTION ACTIVITIES

BOSTON

T. B. Jefferson, Editor of *The Welding Engineer*, addressed the March 12th meeting on "Welding in the Post-War World." A film, "Let Us See," was shown through the courtesy of the Illuminating Engineering Society and is on the subject of proper industrial lighting and the benefits resulting therefrom. Eighty members and guests attended the technical session; 49 attended the dinner at the Engineers Club.

BRIDGEPORT

E. H. Roper, of the Air Reduction Sales Co., was the speaker at the March 15th meeting. Mr. Roper spoke on "Oxy-acetylene Welding and Cutting," illustrating his talk with interesting slides. Thirty-five members and guests were present.

CHICAGO

The Chicago Section is planning its 4th Annual Golf Tournament for Saturday, June 30th, at the Glen Eagles Country Club, Lemont, Ill.

A. B. Kinzel, Union Carbide and Carbon Corp., New York, was the guest speaker at the March 17th meeting of the Section. Dr. Kinzel's subject was "Pressure Welding." In his presentation before the largest audience to attend a welding meeting of the Chicago Section this season Dr. Kinzel brought out some of the points dealing with pressure welding as expressed in his Adams Lecture last fall. In addition he presented considerable information dealing with the practical applications of pressure welding in various fabricating fields, discussing in some detail the more recent uses of pressure welding in the building of a cross-country pipe line and continuous welded rail.

The Fourth Annual War Production Conference sponsored by the Chicago Technical Societies Council was held at the Stevens Hotel, Chicago, Thursday, March 29th. There were 36 panel sessions, two of which were sponsored by the Chicago Section of the AMERICAN WELDING SOCIETY.

The session on resistance welding had as its chairman C. G. Bassler, District Manager, Taylor-Winfield Corp. In addition to a sound movie, "Electronics at Work," provided through the courtesy of the Westinghouse Electric & Manufacturing Co., the following papers dealing with resistance welding were presented: "Some Fundamentals of Resistance Welding," C. L. Pfeiffer, Electrical Engineer, Western Electric Co.; "Aluminum Spot Welding," Carl Otto, Process Engineer, Douglas Aircraft Corp.; "Structural Spot Welding," William Boese, Welding Engineer, Pullman Standard Car Mfg. Co.; and "Electronic Controls for Resistance Welding," T. R. Lawson, Manager Control Section, Westinghouse Electric & Mfg. Co. The meeting closed with a panel discussion conducted by James Cooper, Sales Engineer, National Electric Welding Machine Co.

A second session dealing with arc, gas welding and brazing had as its chairman T. B. Jefferson, Editor, *The Welding Engineer*. The chairman gave a brief talk outlining the importance of welding in the war effort together with recent developments in welding and brazing. Following this there was an "Information Please" session in which T. B. Jefferson acted as moderator with the following "experts" to answer questions relating to various welding, cutting and brazing problems presented by the audience: L. S. McPhee, Welding Supervisor, Whiting Corp.; M. H. Wigton, Research Engineer, Bastian-Blessing Co.; R. L. Kohlbry, Vice-President, Machinery Welder Corp.; W. C. Pearson, Welding Supervisor, Westinghouse Electric & Mfg. Co.; E. R. Seabloom, Supervising Engineer, Crane Co.; J. B. Quigley, Welding Engineer, Graver Tank & Mfg. Co.; and Dudley Rice, Sales Engineer, Eutectic Welding Alloys.

Eric R. Seabloom, in addition to being co-chairman of the War Production Conference, presented a paper entitled "Hard-Facing for Improved Performance at High Temperatures," in a panel sponsored by the American Society for Metals. Leslie S. McPhee was chairman of the exhibit committee of the Conference. Irving Carlson was Chairman of the welding panels.

CINCINNATI

The regular monthly meeting was held on Monday, March 19th, at the Engineers Club, and was addressed by T. B. Jefferson, Editor of *The Welding Engineer*, who spoke on "Welding in the Post-War World." Mr. Jefferson also told about his experiences at Peck Dam where welding played a very important part in the maintenance of earth-moving equipment.

T. (Tom) E. Raftery, one of Cincinnati Section's charter members has been transferred to Los Angeles by The Linde Air Products Co. He was a Past-Chairman of this Section and had served in all its offices. His many friends will be glad to know his eighteen years' service to the welding industry have been rewarded with this promotion.

Because Rowan Gilbreath, Vice-Chairman, has been transferred to Indiana, the following changes in officers has been made: Ernest F. Cahn to *Vice-Chairman;* Larrey E. Sherman to *Treasurer;* Wm. F. Pahner to *Secretary* (R. R. No. 1, Box 45A, Sharonville, Ohio).

COLUMBUS

The April meeting held on Friday, the 13th, at the Southern Hotel was preceded by a dinner at which Lt. John Jordan of the Columbus Fire Dept. was the dinner speaker. The technical session had as its speaker T. B. Jefferson, Editor of *The Welding Engineer*, who spoke on "Welding in the Post-War World."

DETROIT

At a joint meeting of the Detroit Section and the Detroit Junior Board of Commerce and the Society for the Advancement of Management, held on March 14th, James F. Lincoln, President of The Lincoln Elec. Co. of Cleveland, Ohio, presented an interesting address on "How Incentives Affect the Future of Private Enterprise." Mr. Lincoln's talk covered the correct application of Wage Incentives—the personnel problems it solves, the production problems it licks, and the governmental problems it brings up.

Dinner at 6:30 P.M. in the banquet hall of Horace H. Rackham Educational Memorial was followed by the meeting in the large auditorium.

INDIANA

The March meeting was held on the 23rd at the Y.M.C.A. at Anderson. J. D. Gordon, Sales Manager of the Progressive Welder Co. of Detroit, gave a very interesting talk, well illustrated by slides, on "Welding as It Affects Design." Following the talk, films on European war scenes, the V-bomb and Major League baseball were shown.

KANSAS CITY

O. F. Wilkinson, Supervisor of the Applied Engineering Department, St. Louis Office, Air Reduction Sales Co., presented a paper on "Welding and Cutting in Locomotive Maintenance" at the March 20th meeting. His excellent slides clearly illustrated the many ways welding and cutting can be used not only in maintenance and repair work on locomotives, but also in the fabrication of new units.

Two recent Navy sound films were presented, "Target—Japan" and "Pacific Fire Power."

LEHIGH VALLEY

The April meeting of the Lehigh Valley Section was held on the 2nd at the Hotel Bethlehem, Bethlehem, Pa. The first speaker to be introduced by Chairman Kenworthy was Clyde T. Bishoff, Character Analyst of Allentown, Pa. His talk was interesting, entertaining and educational. Mr Bishoff explained the science of character analysis from handwriting

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WELDERS KNOW THEY'RE *Uniform*

...WE KNOW WHY...

• Stainless steel fabricators are rapidly finding out one fact about PAGE-*Allegheny* stainless steel electrodes.

They can be depended upon for uniformity.

We know *why* they're uniform. It is because of our rigid control of every manufacturing process—from drawing the wire to final inspection of the finished electrode . . . constant check on wire and coating . . . frequent tests under actual working conditions.

Experienced welders take PAGE uniformly high quality for granted.

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In addition to a complete line of stainless steel, your PAGE distributor offers a wide range of PAGE Hi-Tensile electrodes and gas welding rods. The benefit of long experience in selecting the one best rod for each welding job is yours when you

Get in touch with Page!

Welding Stainless Steel? *This booklet contains much new, up-to-date information on the subject. Ask your* PAGE *distributor for a copy. Or, if you prefer, write to the factory in Monessen, Pa.*

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AMERICAN CHAIN & CABLE

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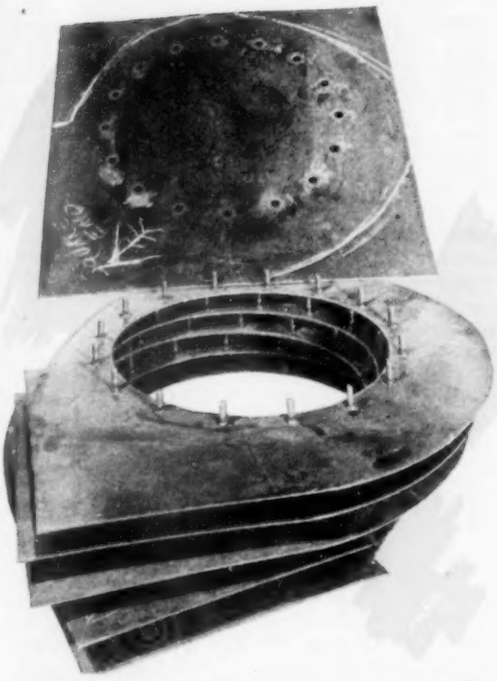

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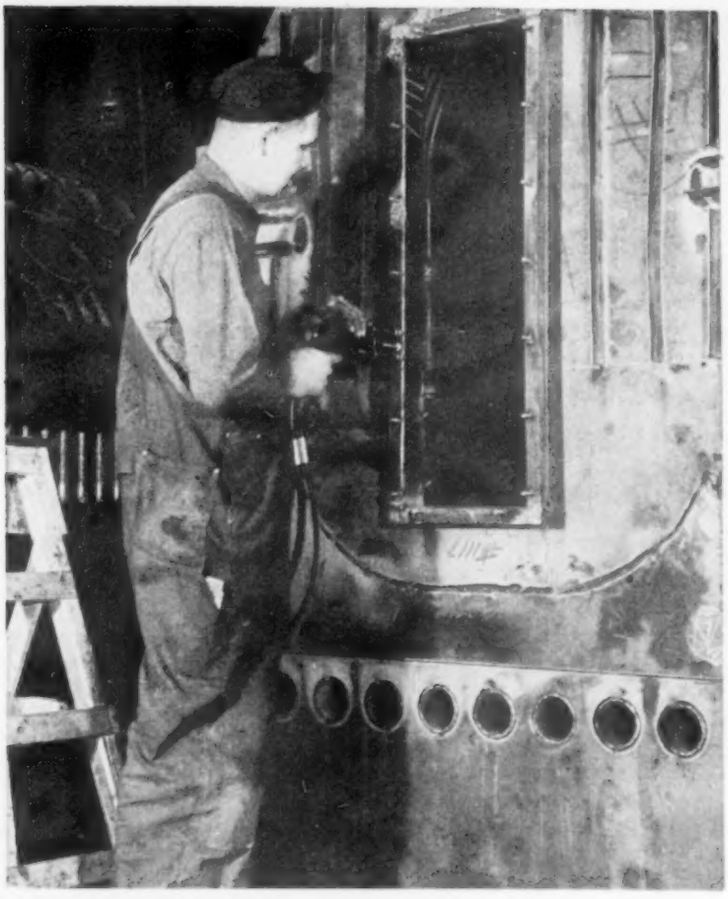

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Welding inspection door on industrial furnace through template. All arc timing is automatically controlled, producing consistent welds. Write today for catalog and complete details.

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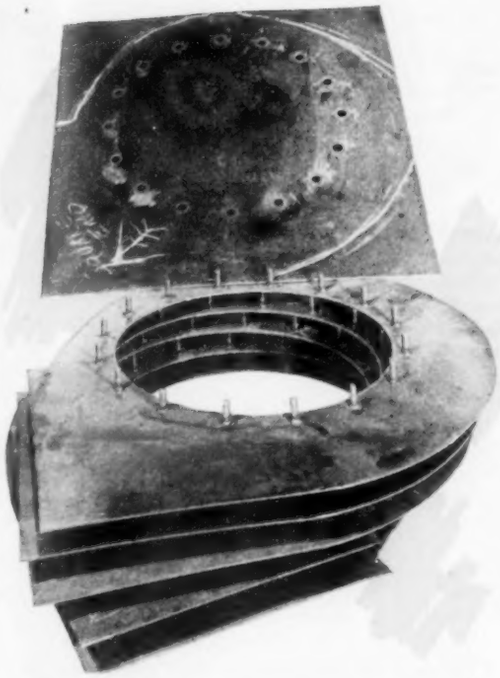

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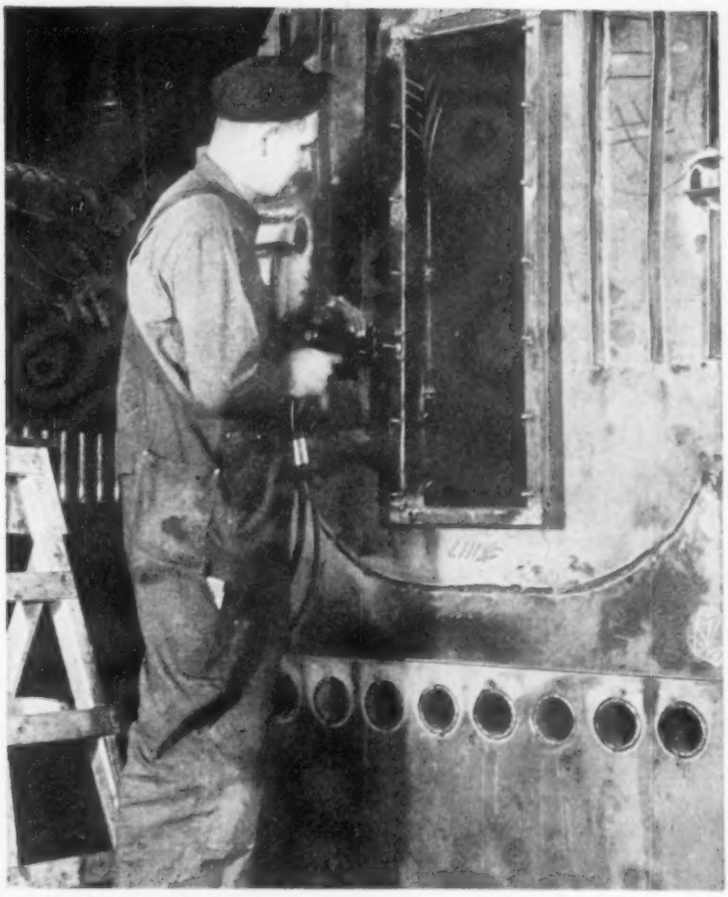

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O. F. Wilkinson, Supervisor, Applied Engineering Department, Air Reduction Sales Co., St. Louis, Mo., on "Welding and Cutting in Locomotive Maintenance."

PASCAGOULA

In an unusually enlightening address of interest to all shipbuilding people, E. B. Thompson, Sales Engineer of the A. O. Smith Corp. of Houston, Texas, discussed the past, present and future of welding, at the regular monthly dinner meeting of the Pascagoula Section of the AMERICAN WELDING SOCIETY in the USO Hall in Pascagoula, Tuesday night, March 27th.

The business session at 8 o'clock was preceded by an appetizing steak dinner at 7 o'clock, with fifty SOCIETY members and others in attendance. W. B. Bowen, Ingalls Welding Superintendent and Chairman of the Pascagoula Section, opened the meeting and introduced three members of the Mobile Section who were guests of the group.

The subject of Mr. Thompson's talk was "What the A. O. Smith Corporation Is Doing in Welded Construction." He pointed out that the future of welding appears very bright, and that we will tend more and more to use high-tensile, low-alloy steels in order to lighten, to a considerable degree, the weight of future welded products. His talk was illustrated with a large number of clear photographic views thrown on the screen. The Smith Corp. is one of the pioneer companies in the welding industry.

Robert H. Mach, Chief Planning Engineer of the Ingalls Shipbuilding Corp., spoke at the monthly dinner meeting of the Section, held at the USO Tuesday night, April 24th. His talk dealt with "Diesel Electric Locomotives."

PEORIA

A Ladies' Night Dinner Dance was held by the Peoria Section on March 17th and was attended by 125 couples. Herman Hampy's orchestra provided the music for both the dinner and the entertainment which followed. While Margaret Ehrhart sang Irish songs, she passed green carnations to the ladies and then to the men. Since it was Ladies' Night, door prizes were given only to the ladies. John Fisher sang "My Wild Irish Rose."

PHILADELPHIA

An occasion which will be long remembered was the Twenty-fifth Anniversary Dinner of the Philadelphia Section held at the Engineers Club Auditorium, Monday evening, March 19th. The Program Committee, composed of W. W. Barnes, R. D. Thomas and T. M. Jackson, started the evening off with a reception for the guests which was followed by an excellent roast beef dinner.

The Philadelphia Section was the first Section of the SOCIETY, organized on February 26, 1920. On that occasion, the principal speaker was Dr. Comfort Avery Adams, then President of the AMERICAN WELDING SOCIETY. William W. Barnes was appointed chairman of the Organization Meeting and H. J. Grow, Secretary.

The first general meeting was held on March 11, 1920, with some 800 persons in attendance.

Affiliation was made with the Engineers Club of Philadelphia, which has since been the permanent headquarters of the Section.

On the occasion of the 25th Anniversary it was entirely fitting that William W. Barnes was appointed Master of Ceremonies. Mr. Barnes introduced the Past-Chairmen of the Philadelphia Section, starting with J. Brogden, who was Chairman during the first year. Quite a number of the Past-Chairmen were present, including the following:

J. Brogden (1920), J. W. Meadowcroft (1924), P. A. L. Maurhoff (1925 and 1926), R. D. Thomas (1927 and 1928), J. J. Dunne (1929 and 1930), L. H. Christensen (1931 and 1932), W. F. Carson (1935), C. I. MacGuffie (1936), T. M. Jackson (1937), H. R. Salisbury (1939), H. W. Pierce (1942).

Among the National Officers who were present and presented brief addresses were President A. C. Weigel and National Secretary M. M. Kelly.

Among the honored guests were J. W. Meadowcroft, R. D. Thomas, T. M. Jackson, W. W. Barnes, Joel Brogden, E. F. Enright and L. H. Christensen, all of whom were among the founder members of the SOCIETY. Other honored guests were R. E. McFarland, Past-Chairman of the Chicago Section, Dr. Wm. Theisinger, recently nominated as District Vice-Chairman for the 2nd District, and W. Spraragen, Editor.

Dr. Samuel Steinmetz, prominent Episcopal rector of Trenton, N. J., was the after-dinner speaker and entertained the 200 members and guests with a series of amusing stories and incidents, and at the same time brought home the need for looking ahead rather than backward and the necessity for mutual cooperation understanding and faith.

As at the Organization Meeting twenty-five years ago, Dr. Comfort Avery Adams was the principal speaker. Dr. Adams traced the origin of the AMERICAN WELDING SOCIETY as an outgrowth of the work of the Welding Committee of the Emergency Fleet Corporation. He briefly reviewed the twenty-five years of accomplishment of the SOCIETY and paid special tribute to two departed members—past-presidents—Samuel Wylie Miller and Charles A. McCune.

Dr. Adams also stressed the research work of the SOCIETY under the present Welding Research Council and under the American Bureau of Welding. He also referred to the first Journal published by the SOCIETY and some of the questions which were raised in that issue. He paid tribute to the work of H. M. Hobart, now retired, who at that time was Chairman of the University Research Committee.

Final meeting of the season will be held on May 21st at the Engineers Club. A. B. Kinzel, Union Carbide and Carbon Co., will speak on "Recent Metallurgical Developments."

PORTLAND, ME.

The Portland Section held its March meeting on the 29th at the Elks Home. The 42 who were present enjoyed a semi-shore dinner and heard a fine address by Prof. P. E. Kyle of Massachusetts Institute of Technology, on "Metallurgy of Welding." Slides were used for illustration and nearly everyone entered into the open discussion which followed.

ROCHESTER

Charles H. Jennings of the Westinghouse Electric & Mfg. Co., discussed the subject "Distortion Problems in Welding" at the April 9th meeting held in the Lower Strong Auditorium, University of Rochester River Campus. Fundamentals controlling the distortion resulting from welding were considered both from the theoretical and practical aspects. Residual stresses and methods of eliminating them were discussed.

ST. LOUIS

The regular monthly meeting was held on March 9th at the Engineers' Club. "Metallurgy in Welding" was presented by R. B. Lincoln, Director, National Weld Testing Bureau, a Division of Pittsburgh Testing Laboratory. Mr. Lincoln's talk was profusely illustrated with slides, and presented in a manner so that it was completely understood by everyone present.

The St. Louis Section is sponsoring a monthly publication entitled "Welding Sparks," the first issue of which was dated March 1945.

SAN FRANCISCO

The February meeting of the San Francisco Section was held at the Bethlehem Steel Co., Fabricating Division Plant, Alameda, Calif., on Friday, February 23rd. Chairman C. M. Doggett presiding. There were 123 members and guests in attendance.

R. E. Gauthier, District Engineer, Bethlehem Steel Co., addressed the assembly.

The meeting adjourned at 9:15 P.M. Immediately thereafter, the group was escorted through the Fabricating Steel Division Plant and aboard the largest troop ships ever built on the Pacific Coast.

Orchids to Mr. Zuckerman and his co-workers for the very excellent manner in which this tour was conducted.

SOUTH TEXAS

George L. Wiley, Welding Engineer for Big Three Welding Equipment Co., talked on "Positioned Welding" at the March 16th meeting. The Harnischfeger Corp. furnished very interesting and educational pictures on "New Horizons in Welding."

SYRACUSE

Walter T. Brooking of R. G. LeTourneau, Inc., was the guest speaker at the April 12th meeting held at the Syracuse Mus um of Fine Arts. Mr. Brooking's subject was on "Arc Welding Production of Heavy Earth Moving Equipment."

Better Welds

Low Temperature

WELDING RODS

EUTECTIC welds are: SMOOTHER • STRONGER • BETTER COLOR MATCHED • MORE MACHINABLE • FASTER TO MAKE and REQUIRE LESS HEAT, avoiding distortion, stresses and overheating

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Metallurgists and welders have long been aware of the tremendous advantages welding at *Low Temperatures* would have in metal joining. If it were possible to gain the advantage of the strong bond formed by fusion welding without resorting to high temperatures, the ideal in welding would be achieved and an all-round better weld obtained.

EUTECTIC *Low Temperature* Welding, the most revolutionary welding development of modern times, enables you to weld joints at temperatures *below the fusion points of base metals*—eliminating the many hazards of high temperature fusion welding.

All metals can be joined by the EUTECTIC process. No special skill is required . . . no extensive training needed. All standard methods of heating are employed: Gas—Arc—Furnace and others in combination with the new EUTECTIC Welding Rods and Fluxes.

If you have Oxy-Acetylene or Arc welding equipment all you need is an assortment of Eutectic Rods in order to add this important improvement to your equipment. Get the facts today! Fill in the coupon at once for full information.

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EUTECTIC WELDING ALLOYS COMPANY
Originators of Eutectic *Low Temperature* Welding
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40 Worth Street, New York 13, New York Room 1110F

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Company _____ Position _____

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City _____

TIDEWATER

The regular monthly meeting of the Tidewater Section of the AMERICAN WELDING SOCIETY was held Tuesday, March 13th, at 8:00 P.M. in the Fleet Reserve Hall, 305 High St., Portsmouth, Va.

The meeting was called to order by C. O. Barham, chairman, who also introduced the speaker, A. N. Kugler, representative of Air Reduction Sales Co., New York.

Mr. Kugler gave a very interesting and educational lecture on welded jigs and fixtures, and general gas welding and brazing practices, which he illustrated by the use of lantern slide pictures. He also related various experiences he has had in his line of work, during the vast expansion period of production; and the many miracles that have been performed, by the use of jigs, and the various metal cutting and welding equipment.

The meeting was adjourned, and light refreshments were served.

Approximately 50 members and guests were present.

TULSA

The following officers and directors have been elected by the Tulsa Section and have taken office as of March 15th:

Chairman, James G. McIlhiney; *Vice-Chairman*, R. L. Looney; *Secretary*, James B. Davis; *Treasurer*, Cecil Wells.

Directors: H. E. Krause, J. F. McKelvey, J. C. Holmberg and F. D. Davenport.

Directors who have 1 more year to serve; Emil C. Hinkefent, Parker Patterson, J. C. McKinley and Jake Neet.

WASHINGTON, D. C.

At the regular monthly meeting held on the 13th of March, Mr. Ira T. Hook, Research Engineer, American Brass Co., addressed the members and guests on the subject "Copper and Copper Alloys in War and Peace." Many important properties of the metals were interestingly presented by a color film, "Copper Goes to War." A most interesting discussion period followed.

WESTERN MASSACHUSETTS

Mr. Arthur Gray, of the Haynes Steel Co., was the guest speaker at the February meeting. Mr. Gray presented an excellent talk on hard surfacing with various types of rods. His talk was illustrated by several excellent slides. An interesting question and answer period followed. A sound movie, "Manufacturer of Stainless Steel," was presented. Fifty-four members and guests were present.

WESTERN MICHIGAN

L. S. Marsh, Metallurgical Consultant for Inland Steel Co., Chicago, spoke at the March 26th meeting of this Section on the subject "Why the Steel Industry Is Interested in Welding." A technicolor movie was also shown.

YOUNGSTOWN

The Youngstown Section held its best meeting of the season on March 15th. Sixty members and guests heard Mr. G. N. Sieger, President of S.M.S. Corp., Detroit, present an interesting lecture on "The Story of Resistance Welding," which was followed by a lively discussion. J. F. Maine, Vice-President of District No. 4, helped in making this meeting a success and brought with him a delegation from the Cleveland Section. Ben L. Wise was instrumental in promoting a large turnout from Warren.

List of New Members

March 1 to March 31, 1945

BOSTON

Avery, Paul F. (B), Avery & Saul Co., 297 Dorchester Ave., S. Boston 27, Mass.

Bell, Frederick J. (C), 243 North St., Saco, Me.

Foley, Thomas F. (C), Avery & Saul Co., 297 Dorchester Ave., S. Boston 27, Mass.

Harris, Chapin E. (B), Avery & Saul Co., 297 S. Dorchester Ave., S. Boston 27, Mass.

Hutchins, Roger D. (C), Northwood Ridge, N. H.

Johnson, Richard C. (B), Avery & Saul Co., 297 Dorchester Ave., S. Boston 27, Mass.

La Plant, Chas. F. (B), Avery & Saul Co., 297 Dorchester Ave., S. Boston 27, Mass.

Purdy, F. J. (C), 81 Jaffrey St., E. Weymouth, Mass.

Scott, Roger M. (C), New England Butt Co., 304 Pearl St., Providence, R. I.

Shelton, Albert E. (B), 308 Lake St., Belmont, Mass.

Taylor, Van Ness (B), Avery & Saul Co., 297 Dorchester Ave., S. Boston 27, Mass.

Walsh, Thomas B. (B), Avery & Saul Co., 297 Dorchester Ave., S. Boston 27, Mass.

BRIDGEPORT

Skibo, Joseph R. (B), Laurel Pl., Derby, Conn.

BRUNSWICK

Bates, Ralph L. (B), 6053 Drive 6, Brunswick, Ga.

CHATTANOOGA

Jones, Albin O. (B), 327 Lincoln Ave. S., Fayetteville, Tenn.

CHICAGO

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Dewees, C. B. (C), P. O. Box 233, Clarendon Hills, Ill.

Fisher, A. (B), 6601 S. Oak Park, Chicago 38, Ill.

Foley, Russell W. (B), Foley & Lavish Eng. Co., 2219 W. Ogden Ave., Chicago 12, Ill.

Foley, Wm. J. (B), Chicago Welded Prods. Co., 1109 W. Belmont Ave., Chicago 13, Ill.

Fox, Jules J. (C), Lepel High Frequency Labs., Inc., 230 E. Ohio St., Chicago 11, Ill.

Gregson, Milo August (B), International Harvester Co., East Moline Wks., E. Moline, Ill.

Grill, Milton J. (C), 4149 N. Keystone Ave., Chicago 41, Ill.

Hanert, Edwin (B), 2034 W. James St., Chicago 9, Ill.

Hertel, Jerome P. (C), Murray Iron Wks. Co., Burlington, Iowa.

Hoeller, Robert L. (C), 7304 S. Emerald Ave., Chicago 21, Ill.

Jorand, Melvin C. (B), 909 W. 76th St., Chicago 20, Ill.

Lavish, Joseph G. (B), Foley & Lavish Eng. Co., 2219 W. Ogden Ave., Chicago 12, Ill.

Lewis, Fred H. (B), Wall Chemicals Div., Liquid Carbonic Corp., 3100 S. Kedzie, Chicago, Ill.

Maver, George E. (C), 4940 E. End Ave., Chicago 15, Ill.

Nowak, Stanley (B), 4242 W. Adams St., Chicago 24, Ill.

Sills, Edward B. (B), Master Industries, Inc. 2415 S. Prairie Ave., Chicago, Ill.

Taylor, E. Winthrop (B), S. G. Taylor Chain Co., Box 509, Hammond, Ind.

Villegas, Roman (C), P. O. Box 166, E. Chicago, Ind.

Yuscka, Paul Andrew (C), 1801 S. 50th Ave., Cicero 50, Ill.

CINCINNATI

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CLEVELAND

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Braun, J. F. (B), Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.
Craig, W. H. (B), Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.
Deucher, Albert E. (B), Albeflo Welding Co., 6510 St. Clair Ave., Cleveland 3, Ohio.
Fox, L. J. (B), Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.
Hrabak, Edward (B), Albeflo Welding Co., 6510 St. Clair, Cleveland, Ohio.
Morley, Edgar (C), Champion Rivet Co., E. 108th & Harvard Ave., Cleveland, Ohio.
Oldenkamp, Henry A. (B), Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.
Powar, Manuel M. (B), Welding & Cutting Supply Co., 2401 Carnegie Ave., Cleveland 15, Ohio.
Spisak, A. A. (B), Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.
Williams, James D. (B), Warner & Swasey Co., 5701 Carnegie Ave., Cleveland 3, Ohio.
Willing, Richard E. (B), Box 3021, Euclid, Ohio.

COLUMBUS

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Martin, David C. (C), Battelle Memorial Inst., Columbus, Ohio.
McDonald, Solon (C), 7 Elmwood Ave., Mt. Vernon, Ohio.
Reiser, Wm. O. (C), Williams & Co., Inc., 31 N. Grant Ave., Columbus, Ohio.
Rieppel, Perry J. (C), 350 Kinbrook Dr., Worthington, Ohio.
Thompson, Walter M. (B), Colo. A. S. F. Depot, 169 Grant Ave., Grove City, Ohio.

DETROIT

Bartch, Maura J. (B), Master Welded Prods. Co., 8620 Gratiot, Detroit 13, Mich.
Bayer, Peter C. (B), 625 E. Grand Blvd., Detroit 7, Mich.
Clark, H. R. (B), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
Crampton, Geo. W. (B), La Salle Elec. & Mill Supply Co., 1360 Franklin St., Detroit 7, Mich.
Cummiskey, M. T. (B), La Salle Elec. & Mill Supply Co., 1360 Franklin St., Detroit 7, Mich.
Dadson, James C. (C), Robinson Welding Supply, 1951 E. Ferry St., Detroit, Mich.
Fischer, George (C), Harris & Fischer Iron Wks., 1105 S. Water St., Saginaw, Mich.
Gilbert, Walter E. (B), Detrex Corp., 13005 Hillview Ave., Detroit 27, Mich.
Hadley, Fred F. (B), 834 Church St., Plymouth, Mich.
Harris, Marshall (C), Harris & Fischer Iron Wks., 1105 S. Water St., Saginaw, Mich.
Hathaway, B. (B), L. A. Young Steel & Wire Corp., 9200 Russell St., Detroit 11, Mich.
Johnson, Floyd A. (B), La Salle Elec. & Mill Supply Co., 1360 Franklin St., Detroit 7, Mich.
Joiner, W. S. (B), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
Lee, Chas. (B), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
Liu, Capt. Ping-Nan (C), Y.M.C.A., Flint, Mich.
Martin, Calvin M. (C), 915 Lapeer St., Saginaw, Mich.
Moxlow, Wm. E. (B), La Salle Elec. & Mill Supply Co., 1360 Franklin St., Detroit 7, Mich.
McDaniel, Harry K. (C), McDaniel Welding, 714 N. Saginaw, Holly, Mich.
McFadden, T. E. (B), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
McKinstry, Thos. O. (B), La Salle Elec. & Mill Supply Co., 1360 Franklin St., Detroit 7, Mich.
Mullen, Henry A. (B), 866 Simpson St., Plymouth, Mich.
Nelson, G. P., L. A. Young Steel & Wire Corp., 9200 Russell St., Detroit 11, Mich.
Rankins, Fred D. (B), Master Welded Prods. Co., 8620 Gratiot, Detroit 13, Mich.
Renwick, R. J. (B), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
Smith, Louis J. J. (B), La Salle Elec. & Mill Supply Co., 1360 Franklin St., Detroit 7, Mich.
Sonneborn, Arthur B. (A), Natl. Electric Welding Machines Co., 631 Fisher Bldg., Detroit 2, Mich.
Stafford, W. (C), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
Van Hove, H. (B), L. A. Young Steel & Wire Corp., 9200 Russell St., Detroit 11, Mich.
Walker, J. A. (B), Ford Motor Co. of Canada, Ltd., Windsor, Ont., Canada.
Wei, Chao-Yung (C), 331 Y.M.C.A., Flint, Mich.

INDIANA

Bauer, Edna B. (C), R. 6, Anderson, Ind.
Grimes, William Frederick (C), 8070 E. Circle Dr., Dayton 5, Ohio.
Heldt, Orville E. (B), 27 S. Downey Ave., Indianapolis, Ind.
Hicks, Earl M. (C), Hicks Body Co., 510 Indianapolis Ave., Lebanon, Ind.
Wahl, Clarence W. (C), Hicks Body Co., 510 Indianapolis Ave., Lebanon, Ind.
Wilhelm, O. H. (C), National Cylinder Gas Co., 909 N. Capitol Ave., Indianapolis, Ind.
Williams, C. Walter (B), 343 N. Ritter Ave., Indianapolis 1, Ind.

KANSAS CITY

Clark, E. E. (C), 315 W. 9, Kansas City, Mo.
Park, C. A. (C), 109 N. Gladstone, Kansas City 1, Mo.

LEHIGH VALLEY

Hendricks, Howard W. (C), 614 Ontario St., Bethlehem, Pa.
Reuber, Tillman H. (B), Allentown Iron Wks., 250 N. Third St., Allentown, Pa.
Weindel, Frederick J. (B), L. F. Grammes & Sons, Inc., Allentown, Pa.
Wummer, Wm. R. (C), 902 Broadway, Bethlehem, Pa.

LOS ANGELES

Bisbee, Jack E. (C), 11009 Scoville Ave., Sunland, Calif.
Fraser, Geo. F. (C), 207 S. Electric Ave., Alhambra, Calif.
Garrison, Wayne (B), 3200 E. Slauson, Los Angeles 11, Calif.
Grant, R. J. (C), Wilmington Welding & Boiler Wks., 115 N. Marine Ave., Wilmington, Calif.
Hite, Glen Thomas (C), 339 W. 55 St., Los Angeles 37, Calif.
Hoth, H. A. (C), Air Reduction Sales Co., 2423 E. 58 St., Los Angeles, Calif.
Johannsen, Iver H. (C), 2711 S. Willard, Garvy, Calif.
McGrew, Chas. C. (C), 5438 4th Ave., Los Angeles 43, Calif.
Moore, Chas. B. (C), 848 N. Dillon St., Los Angeles, Calif.
Neighbors, Forrest A. (C), 2653 Pine Ave., Garvey, Calif.
Newton, V. C. (C), C. F. Braun & Co., 1000 S. Fremont St., Alhambra, Calif.
Petralia, Jack J. (C), 25 N. 3rd St., Alhambra, Calif.
Smith, Chas. Brent (B), 5916 El Mio Dr., Los Angeles 42, Calif.
Stone, Bert L. (B), Hydril Corp., 1000 Alhambra Ave., Los Angeles 12, Calif.
Uhl, V. A. (C), 427 S. McPherrin Ave., Monterey Park, Calif.
Vincent, John (C), 5250 Via Corona, Los Angeles, Calif.
Wilson, H. D. (C), 809 S. 9th St., Alhambra, Calif.

LOUISIANA

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MARYLAND

Betz, Talbot H. (B), 5217 Eastern Ave., Baltimore 24, Md.
Brocato, Vincent Paul (C), 617 Melville Ave., Baltimore 18, Md.
Higinbothom, Francis (C), 5737 First Ave., Halethorpe, Md.
Moore, Joseph W. (C), 7215 Harford Rd., Baltimore 14, Md.
Zink, John H. (B), Heat & Power Corp., 428 E. Saratoga St., Baltimore 2, Md.

MICHIANA

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Jessup, Kenneth (C), 306 W. Wayne St., Dowagiac, Mich.

MILWAUKEE

Horton, Chet T. (B), 2724 N. Stowell Ave., Milwaukee 11, Wis.
Te Luidert, Geo. (C), Optenberg Iron Wks., Cedar Grove, Wis.
Wepfer, Geo. R. (C), 1530 N. 38th St., Milwaukee 8, Wis.
Wolfe, M. J. (B), The Wolfe-Kote Co., 705 Center Ave., Sheboygan, Wis.

NEW JERSEY

Babish, John P. (C), 628 Magnolia Ave., Elizabeth, N. J.
Crothers, James D. (C), Asbury & Hudson Ave., Atlantic Highlands, N. J.
Forlenza, Al (C), Century Welding & Fabricating Co., 33 Adelaide St., Belleville, N. Y.
Funai, George (C), 160—4th Ave., Brooklyn 17, N. Y.
Herbst, H. T. (B), The Linde Air Products Co., 686 Frelinghuysen Ave., Newark 5, N. J.
Hescock, Ethan A. S. (C), 142 Mohawk Dr., Cranford, N. J.
Lentoski, Henry (C), 401 N. Grove St., E. Orange, N. J.
Merola, Montano (C), 618 Elm St., Arlington, N. J.
Moore, C. R. (C), Ironia Rd., Mendham, N. J.
Ott, Clarence T. (C), 1866 Hudson Blvd., Jersey City, N. J.
Schick, J. J. (C), 78 North Ave., Fanwood, N. J.

Schmidt, Frank (C), 655 Ferry St., Newark, N. J.
Visco, Miss Dora C. (C), 252 E. 117th St., New York 35, N. Y.
Yesville, Louis (C), 158 Ward Pl., S. Orange, N. J.
Zimmerman, Henry (C), 1942 Ostwood Terrace, Union, N. J.

NEW YORK

Fandel, John P. (C), 153 St. & Cromwell Ave., Bronx, N. Y.
Horowitz, Wm. J. H. (B), 739 W. 186 St., New York 33, N. Y.
Inman, Nelson S. (B), 1 Abrams Pl., Lynbrook, N. Y.
Neely, Wm. L. (C), 734 W. Outer Dr., Oak Ridge, Tenn.
Preston, Wm. M. (C), 39-26—55 St., Woodside, N. Y.

NORTHWEST

Grohs, W. H. (B), 1378 Blair Ave., St. Paul 4, Minn.
McGonigle, Fred A. (C), Power Tools, 2276 W. Como Ave., St. Paul 8, Minn.
Roal, Ralph (C), 2201 E. 34th St., Minneapolis 7, Minn.

PEARL HARBOR

Ahue, Charles, Jr. (C), 3307 George St., Honolulu, T. H.
Brian, Richard E. (C), 1965 Ala-Wai Blvd. Apt. 8, Honolulu, Hawaii.
Kam, Richard Y. S. (C), 2816 Pauoa Valley Rd., Honolulu 23, T. H.
Potter, Baker W. (C), 2457 Ala-Wai Blvd., Honolulu, T. H.
Shavelenko, Igor A. (C), Progress Section, U. S. Navy Yard, Pearl Harbor, Hawaii.

PEORIA

Johnson, A. W. (C), 708 Laura Ave., Peoria, Ill.
Kinney, John T. (C), Caterpillar Co., Peoria, Ill.
Mahan, Walter L. (C), R. R. 7, Decatur, Ill.
McCowan, Donald E. (C), 5915 S. Madison St., Bartonville, Ill.
Smith, Clyde G. (C), Meyer Furnace Co., R. 2, Washington, Ill.

PHILADELPHIA

Hale, W. C. (C), South Chester Tube Co., Front & Thurlow St., Chester, Pa.
Langley, Clarmont J. (C), 700 Station Ave., (B-100), Haddon Hts., N. J.
Markel, S. E. (B), 1395 New York Ave., Trenton 8, N. J.
Skutta, Frank R. (C), 334 E. Upsal St., Philadelphia, Pa.
Waggoner, Alvin G. (B), 1421 Arch St., Central Y.M.C.A., Philadelphia, Pa.

PITTSBURGH

Warley, E. B. (C), Route 3, Box 93, Wiston, W. Va.

PORTLAND, ORE.

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Foster, R. E. (C), 2112 N. E. 51, Portland, Ore.
Gregg, Duncan S. (B), 4103 Grant St., Vancouver, Wash.
Quarles, James B. (B), 1029 N. E. Thompson, Portland 12, Ore.
Starr, Norman L. (B), 7435 N. Buchanan, Portland, Ore.

PUGET SOUND

Nelander, Harland (C), 6937—31st S. W., Apt. 1138, Seattle 6, Wash.

QUAD CITIES

Flodeen, Albin H. (C), International Harvester Co., Farmall Wks., 505—41 St., Rock Island, Ill.
Graflund, K. T. (C), International Harvester Co., 505—41st St., Farmall Wks., Rock Island, Ill.

ROCHESTER

Haddleton, Herbert (C), 327 N. Drive, Rochester, N. Y.
Lathrop, Norman C. (C), 250 Chili-Gates Town Line Rd., Rochester 1, N. Y.
Lester, Bernard M. (C), 92 Cleon St., Rochester 5, N. Y.
Williams, David G. (B), 21 Perrin St., Fairport, N. Y.

SAN FRANCISCO

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Russell, A. A. (C), P. O. Box 1648, Stockton, Calif.
Staack, Ed (C), 900 High St., Oakland 1, Calif.
Trzyna, B. R. (C), 265 W. 6th St., Stockton, Calif.

ST. LOUIS

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Rathbun, Andrew D. (B), Usona Mfg. Co., 3512 Chouteau Ave., St. Louis 3, Mo.

SOUTH TEXAS

Pennybacker, Percy V. (B), Bridge Div., Texas Highway Dept., Austin 26, Tex.

SYRACUSE

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Schliecker, Louis H. (C), 357 Coolidge Ave., Syracuse, N. Y.

TIDEWATER

Cook, Carlas B. (C), 203 Garrett St. Wm. Ct., Portsmouth, Va.
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Jones, P. J. (B), 22 Jewell Ave., Portsmouth, Va.
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WASHINGTON, D. C.

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Dawson, Walter F. (C), U. S. Navy, Bureau of Yards & Docks, Drydock Section, Main Navy Bldg., Rm. 2449, Washington, D. C.
Kram, Ens. Harvey I. (B), U.S.N.R., U.S.N. Mine Warfare Test Station, Solomons, Md.

WESTERN MICHIGAN

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WESTERN NEW YORK

Binkley, H. O. (B), Industrial Welding Co., 1126 Whitney Ave., Niagara Falls, N. Y.

WICHITA

Houser, K. O. (B), 528 S. Belmont, Wichita 9, Kan.
White, Roy (B), 1425 S. Wichita St., Wichita, Kan.

Note: "List of New Members" who joined in March and other members who were reclassified, will be continued in the June issue.

LINCOLN GOLD MEDAL AWARD OF THE AMERICAN WELDING SOCIETY

Papers received for publication in THE WELDING JOURNAL of the AMERICAN WELDING SOCIETY describing clearly original work done by the author or authors or under their supervision on welding in any of its aspects by any method or process are eligible for this year's award of the Lincoln Gold Medal if they appear in or before the July issue of THE WELDING JOURNAL and also have been delivered or scheduled for delivery before a meeting of the AMERICAN WELDING SOCIETY or a meeting of any section or division of the Society. Papers received too late for publication before that time will be eligible for the 1946 award if they are delivered or appear in THE WELDING JOURNAL in any of the succeeding twelve months.

The Lincoln Gold Medal is awarded annually to the author or authors whose paper is chosen by the Board of Awards of the AMERICAN WELDING SOCIETY as the greatest original contribution to the advancement and use of welding. Other requirements for eligibility are that a paper must be a full disclosure of the subject treated and that it shall contain no unethical advertising or sales promotion. Papers having more than three authors are not eligible. Authors need not be members of the AMERICAN WELDING SOCIETY.

The donor of the annual award is Mr. J. F. Lincoln, President, Lincoln Electric Company. The presentation is made each year at the Annual Meeting of the Society and, when papers have joint authors, each author received a medal and a certificate of award.